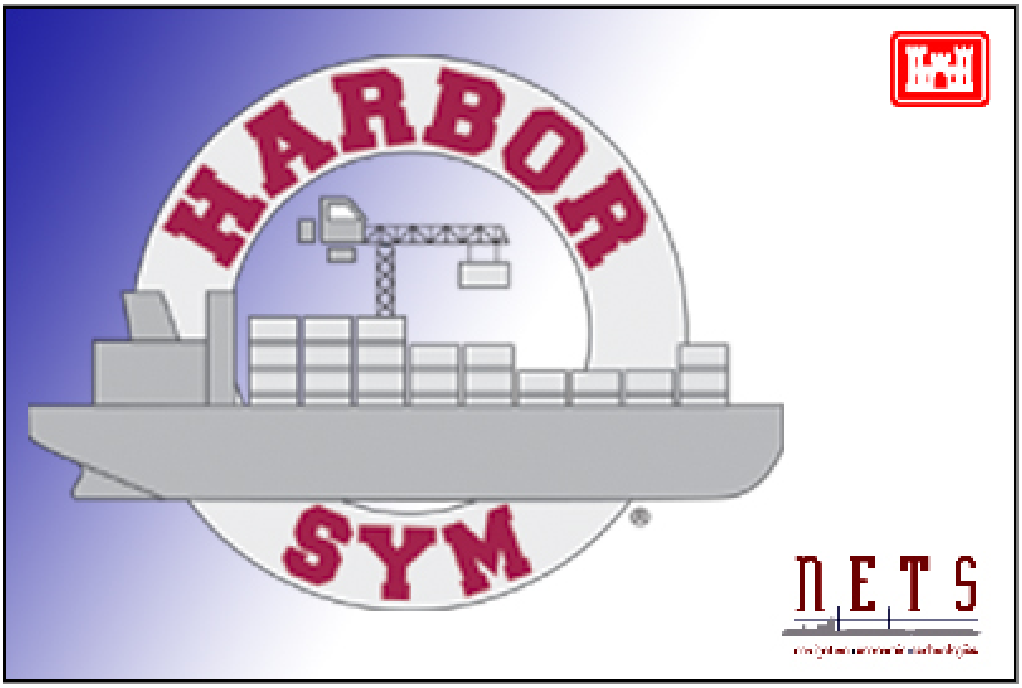
HarborSym Application User's Manual



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HarborSym Kernel Version 1.0.26.3
Container Loading Tool Version 0.6.14.0
Bulk Loading Tool Version 1.0.88.0
Combiner Version 1.0.4.0

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Section 1

Introduction

This document provides a basic user's manual for the Harbor System simulation (HarborSym) software. HarborSym is an economic analysis model, developed by the U.S. Army Corps of Engineers (Corps) Institute for Water Resources (IWR), for use in examination of deep-draft channel improvements. HarborSym is a discrete event Monte Carlo simulation model and is designed to be a general-purpose tool for use by Corps planners. HarborSym is part of a suite of similar IWR-developed models, all with a similar architecture and approach of "data-driven" modeling, in which the factors that tailor a general-purpose model to a specific situation and study are stored in a database and populated by the user. The model measures the economic effects of modifications to deep draft harbors as overall reductions in transit times and associated changes in total vessel operating costs. The model is oriented primarily towards improvements that reduce congestion in the waterway or increase vessel operating efficiencies, as opposed to landside materials handling improvements, although changes to loading/unloading times can be represented. The simulation results can be used in a comparative analysis of alternative harbor improvements and to support a general benefit-cost analysis of proposed navigation improvements.

The node network representation of the harbor is built by the HarborSym user. Then the vessel classifications, commodity categories, and basic vessel call information are defined by the user. The HarborSym model uses these inputs to simulate vessel traffic in user-defined scenarios. The user is provided many input options that allow flexibility in simulating vessel traffic.

HarborSym was initially developed as a tool for analyzing channel widening projects, which were oriented toward determining time savings or vessels transiting a harbor but did not, in general, involve assessing changes in vessel loading or shipping patterns. The latest HarborSym release, toward which this manual is geared, is designed to assist analysts in evaluating channel deepening projects in addition to the original model capabilities. The additional deepening features captures fleet and loading changes, incorporates calculations for both within harbor costs and costs associated with ocean voyage costs, and includes three tools designed to aid planners in analyzing and developing future vessel calls lists for general bulk and containerized vessels.

The Bulk Loading Tool (BLT), Container Loading Tool (CLT), and Combiner have been incorporated into HarborSym. The BLT and CLT are integrated modules within HarborSym designed to generate synthetic vessel call lists based upon user provided calling statistics. The Combiner can be used to merge the BLT and CLT produced vessel call databases into a single database that can be used by the HarborSym simulator. While users are not required to generate future call lists through the modules, this feature greatly enhances the HarborSym capabilities by simplifying the process of populating future conditions.

HarborSym is a complicated model requiring detailed user-provided data and assumptions. Attending a training class will provide users a more thorough understanding of the workflow, model capabilities, and data requirements. In the absence of an instructor-led session, training materials are available for download from the HarborSym website. The training materials are composed of a series of software exercises that walk the user through the required steps to create a study network, populate data, run a simulation, and analyze outputs.

This manual is designed as a reference guide and will assist users in understanding specific functions of the HarborSym model. Section 2 of the manual discusses software installation procedures and system requirements. Section 3 provides an overview of the fundamental model concepts and standard features used in the HarborSym application while Section 4 provides the same details for the Loading Modules. Section 5 details the basic menu commands and functions within HarborSym, addressing each menu item. Section 6 describes how to develop a new HarborSym project and Section 7 discusses generation of a synthetic vessel call list. Section 8 describes simulation settings and setting up scenarios and Section 9 how to use HarborSym output to compare projects. Section 10 introduces the HarborSym Animation Module (HSAM), a post-process animation tool. The five appendices provide additional details on importing data into HarborSym, traffic rules, and output files of both HarborSym and the Loading Modules. A Glossary of Terms and Index are provided at the end of this document.

Section 2

Installation

The HarborSym software is primarily distributed by Internet download, although it can also be distributed by CD-ROM, upon request.

2.1 System Requirements

Before installing HarborSym, make sure the computer system meets the following hardware and software requirements:

- Minimum 1 GHz processor
- Microsoft Windows XP or Windows 7
- 1 GB RAM
- 200 MB available hard disk space
- CD-ROM or Internet connection
- Administrator permissions on the computer for installation purposes

If you encounter any issues installing on Windows 7, please contact the HarborSym Design Team at harborsym@usace.army.mil. If an earlier version of HarborSym was installed on the system, please be sure to uninstall that version following the directions provided in Section 2.4.

2.2 Installation Procedures

CD-ROM Installation:

1. Insert the HarborSym CD-ROM into your CD-ROM drive.
2. Wait for the setup program to start.
3. Follow the instructions to complete setup; it is recommended for users to accept all default settings.

Internet Download Installation:

1. Download the installation file to a temporary directory (Example, C:\Temp).
2. Click the start button on the Taskbar.
3. Click Run.
4. Type the path to the downloaded file (Example, C:\Temp\Setup.exe).
5. Click the “OK” button.

6. Follow instructions to complete setup; it is recommended for users to accept all default settings.

2.3 Location of Installed Files

The sample data, training data, and most other databases and templates (exceptions noted below) are stored in the 'Public' documents folder. This location varies according to the Operating System:

- Windows XP or older: "C:\Documents and Settings\All Users\Documents\HarborSym"
- Windows Vista or Windows 7: "C:\Users\Public\Documents\HarborSym"

For the C LT, the new default folder for templates and sample data will also vary according to the Operating System:

- Windows 7 Templates folder: "C:\Users\Public\Documents\HarborSym\Templates"
- Windows 7 CSV save folder: "C:\Users\Public\Documents\HarborSym\Sample Data"
- Windows XP (or older) Templates folder: "C:\Documents and Settings\All Users\Documents\HarborSym\Templates"
- Windows XP (or older) CSV save folder: "C:\Documents and Settings\All Users\Documents\HarborSym\Sample Data"

2.4 Uninstall

1. Click the Start button on the Taskbar.
2. Click Settings.
3. Click Control Panel.
4. Double-click Add/Remove Programs.
5. Select "HarborSym".
6. Click the Add/Remove button.
7. Follow prompts to uninstall.
8. Go to the directory where HarborSym was installed (typically C:\Program Files\HarborSym) and ensure that the entire directory was removed. If it was not, delete the "HarborSym" directory and all of its contents. Navigate to the template/database install locations noted in Section 2.3 and ensure that all folders and files were removed, deleting any files that were not.

Section 3

HarborSym Overview

HarborSym is based on the creation of discrete event Monte Carlo simulations that mimic movements of vessels through a harbor. The systems created in HarborSym have randomized behavior in terms of generation of trips, loading and unloading time at docks, and docking and undocking time. The user inputs statistical parameters with minimum, maximum, and most likely values. The application is designed to estimate the economic effect of channel modifications on transit times and vessel operating costs. HarborSym has been designed with many general features to enhance its portability and can be used to evaluate economic effects of improvements on many harbors. The study area is specified by developing a model of the harbor network that physically and statistically represents the navigation conditions of the desired study area.

The model consists of the following integrated components:

- A Microsoft *Access* 2000® database, storing the harbor representation, statistics on vessel transit times, routes through the system and model output (users do not need to have Microsoft Access installed on their computer);
- A C++ “simulation kernel” that performs the detailed simulation calculations, reading data from the database and storing the output results back in the database and in separate detailed output data files;
- A user interface, written in Visual Basic.NET, allows for data input and editing, graphical display of the system, running of the kernel and output reporting.

The three components work together to satisfy the goal of providing an integrated system for the user. The model includes capabilities to simulate vessel traffic and transit rules in the harbor.

3.1 HarborSym Database Architecture

Understanding of the HarborSym database architecture is helpful in grasping many aspects of the model’s underlying methodologies and how the various components of the model work together. This section provides an overview of the HarborSym databases for reference and to support a comprehensive understanding of the model operations and functionality. As all the information stored in these databases is available through the HarborSym User Interface, users are not expected to enter, view, or modify data directly through the supporting databases.

HarborSym is a data-driven model, with information stored in multiple databases. At present, five databases are required for a HarborSym simulation: 3 for input, 2 for output. The Bulk Loading Tool module (BLT) requires an additional database in order to generate a synthetic shipment list. The Container Loading Tool (CLT) requires three additional databases. All the databases are Microsoft Access™ databases. Each database contains tables (where the data are actually stored), queries (particular views of the data), forms and reports. One of the features of Access is the ability to link information that is actually stored in separate databases, so that, to the user, all of the information appears to be in a single database, but the tables are actually spread over multiple databases. HarborSym uses this architecture to separate and organize the required information. Each database

type is identified by its file extension. The individual databases are not completely independent, for example vessel call information (in the VCDB) references information about individual docks (stored in the IDB), as shown in Table 1.

Table 1: Databases Used In Analysis

Database	File Extension	Contents / Usage
Master Database	MDB	Links together all relevant information needed for HarborSym simulations. Linked databases are the IDB, VCDB and ODB. This database in and of itself does not contain any study-specific content. The study-specific content is contained in the linked IDB and VCDB.
Input Database	IDB	Description of the port, channels, docks and transit rules, as well as vessel types, vessel classes, commodity categories, and route groups.
Vessel Call Database	VCDB	Description of vessels, vessel calls and commodity transfers. Must be associated with an IDB.
Output Database	ODB	Stores output results from multiple runs of HarborSym.
Scenario Output Database	SODA	Stores detailed output associated with a single HarborSym simulation.
Bulk Forecast Database	FCDB	Required by BLT. Stores information about commodity forecasts at docks, constraints on vessel class capability to carry commodities and serve individual docks and statistical information (cumulative density functions and regression equations) needed for synthetic vessel generation. Requires an association with an IDB.
Container Forecast Database	CFCDB	Required by CLT. Stores information about commodity forecasts at docks, services, fleet specifications, forecast seasons, and other vessel class statistics needed for synthetic vessel generation. Requires an association with an IDB.
Geography	MDB	Required by CLT. Stores information about ports and regions. This database in and of itself does not contain any study-specific content.
CLT Generator Master	MDB	Required by CLT. Links together all relevant information needed for CLT generations.

3.2 Basic Concepts

The basic structure of a model developed in HarborSym relies on data to describe the physical layout, vessel traffic, commodity transfers, and traffic rules for vessel movement. A navigation improvement to a harbor changes transit times of vessels in the harbor. All data for each alternative project simulated, along with information on specific data elements used in the simulation and the simulation parameters, is stored in tables within a Microsoft *Access*® database. The scenario provides the combination of data used by the Monte Carlo process that estimates total transportation time and cost of vessels transiting the harbor.

The key features of the model are:

- User defined network describing the port;
- Historical vessel calls, with multiple commodities and docks;
- User definition of vessel classes commodity types, and route groups;
- Tidal influence and internal calculation of tide height and current by reach;

- Transit analysis based on user-parameterized rules;
- Intra-harbor vessel movements;
- Use of turning areas and anchorages;
- Within-Simulation and post-processing visualization and animation;
- Synthetic vessel call list generation for general bulk carriers and containerships.

The subsections below introduce key HarborSym concepts. Additional detail on where and how to enter this information into the HarborSym user interface can be found in Section 6 and in the training materials.

Note that HarborSym data requirements should be expressed in English units. Reach lengths, vessel characteristics, etc must be expressed in feet.

3.2.1 Port

The port is synonymous with the study harbor. The longitude and latitude of the port is entered to allow HarborSym to determine daylight hours at the port, since some transit rules within the port can be specified as daytime or nighttime rules. Users should also provide information on daylight savings time applicability to better represent vessel movements during the simulation.

3.2.2 Harbor, Nodes, Reaches

The port or study harbor is represented as a system of reaches between nodes. A HarborSym reach-node network must be "tree-structured", with only a single path between any two node pairs. Loops, in which multiple pathways between a pair of nodes are possible, are not permitted within a HarborSym network. Reaches cannot cross each other. Nodes represent docks, turning areas, anchorages, entry/exit points or other topologic points in the harbor where channel conditions change. At least one node on the network must be defined as an entry/exit point. Nodes are connected to each other by reaches. A reach represents a channel segment (of uniform characteristics) between two nodes. Vessel movement statistics are calculated based on vessel movement in reaches.

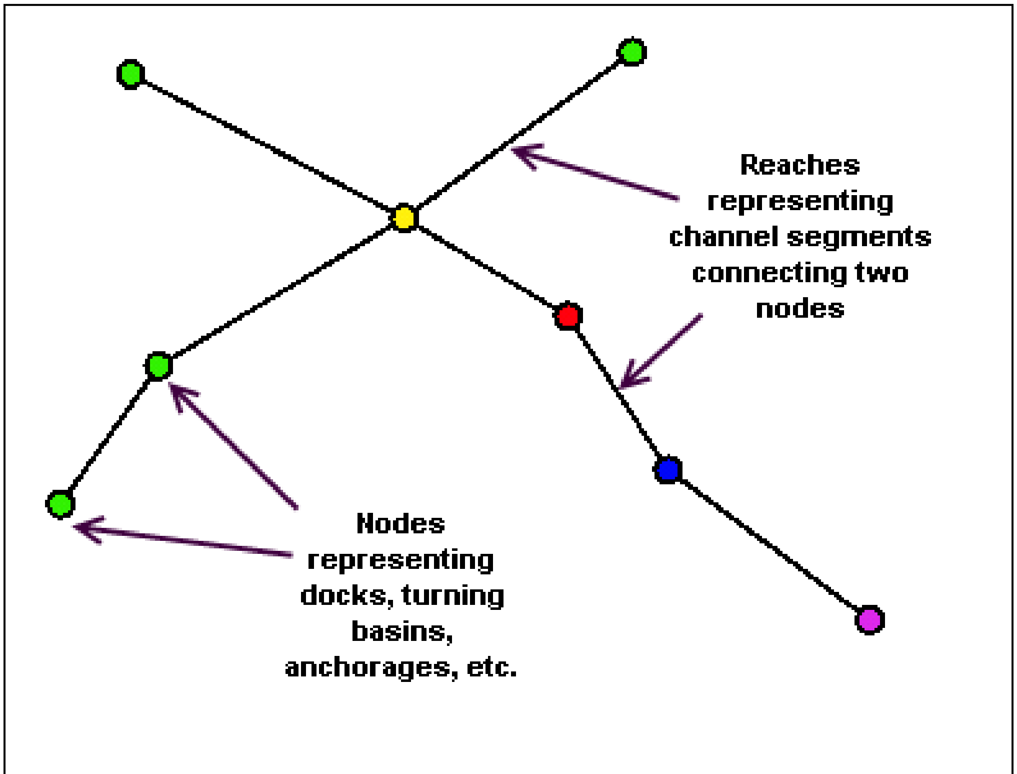

Figure 1: Reach Node Network

Figure 1 depicts a reach-node schematic for a theoretical HarborSym system. This setup allows major harbor features to be represented symbolically to facilitate planning-level analyses. It is important to recognize that the HarborSym network is an abstraction of reality for planning and modeling purposes – multiple docks may be aggregated into single docks and channels may be simplified.

3.2.3 Reach Configuration

The reach configuration data specifies the characteristics of each reach. Reaches are user defined channel segments with uniform characteristics, including width, depth, transit rules, and operating speeds. A reach necessarily connects two nodes within the system. User-specified information for a reach includes a description (name), and the length, width and depth of the channel. The vessel transit speeds through each reach under light and loaded conditions are specified by the user for each vessel classification. These speeds are fixed numbers, not defined by a distribution. The optimal reach configuration will depend upon specific operating practices within the study port. Users should consult channel maps, pilots, port authority representatives, and other sources of direct information when defining their network.

3.2.4 Node Configuration

The users must define all functional nodes to be represented within the simulation system, including system entrance points, docks, turning basins, anchorages. The system entry and exit points must be identified.

The dock configuration data includes the description (name), length, depth, capacity, corresponding turning basin, vessel docking times, and commodity transfer rates.

Turning basins must be defined by vessel capacity and depth, as well as an indication of whether the channel is blocked during vessel turning maneuvers. If the “Blocks Channel” option is selected for a turning basin, while vessels complete their turning maneuvers no other traffic may traverse the adjacent channel. If this option is not selected, traffic through the channel is not impacted by vessel turning maneuvers. In HarborSym, vessels cannot wait within a turning basin. A triangular distribution of minimum, maximum, and most likely time required to utilize the turning basin is required for each vessel type. The determination of which turning basin to use for each dock is defined by user input at the vessel class level, as is the sequence of turning (i.e., before or after docking, or when the vessel is drafting deeper or lighter). Before a vessel is directed to a turning basin, HarborSym will confirm that the vessel’s sailing draft, inclusive of underkeel clearance requirements (if applicable), does not exceed the turning basin depth. If applicable, tidal influence is included in these calculations.

Anchorages, also termed “Facility Nodes” in HarborSym, are defined by the physical characteristics of capacity and depth. Users can also designate that anchorages block the channel, thus prohibiting through-sailing if a ship is stopped in the anchorage. Anchorages can be used as intermediate waiting points if a vessel is temporarily prohibited from reaching its destination (e.g., a dock) due to congestion or constraints. Under these conditions, HarborSym will direct vessels to wait in an available anchorage if the vessel can reach the location of the anchorage without encountering a constraint, there is space available at the anchorage, and the vessel draft, is equal to or less than the anchorage depth. An additional 10’ of available depth is assumed if the vessel is light. As vessels may be delayed for an extended period covering multiple tide cycles, HarborSym does not include tidal influence in the determination of water depth availability.

3.2.5 Vessels and Vessel Calls

The driving parameter for the Monte Carlo simulation is a vessel call at the port. A fleet of distinct vessels services a port, with any one vessel in the fleet calling one or more times during the simulation period. Each such vessel call takes place at a known or generated date and time, is identified with a specific real or synthetically generated vessel and includes one or more dock visits (intra-harbor movements are represented by multiple dock visits within a vessel call). Each dock visit consists of one or more commodity transfers. A commodity transfer is an import and/or export of a known quantity of a given commodity. Vessel calls are obtained either from historical data available at the port that is stored in the database or are generated synthetically, external to the model or using the BLT, CLT, and/or Combiner. Vessel calls are stored in the Access database as a set of related tables. The calculation of transportation costs is contingent upon the composition and quantity of vessel calls. Thus, it is critical that the user-provided vessel calls are a reasonable reflection of the traffic calling the study port or anticipated to call in future conditions.

3.2.5.1 Vessel Types and Vessel Classes

Vessel types are general categories of vessels such as tankers, general cargo vessels, or container vessels, as defined by the user. A vessel type contains one or more. A vessel class belongs to only one vessel type. Vessel classes are subsets of vessel types defined by the user based upon physical parameters (length, beam, draft, capacity, TPI), commodities carried, sailing speeds, sailing drafts, operating costs, and ocean sailing routes. Vessel classes are also defined by the user. Examples of vessel classes could be tanker small, tanker large, Panamax, Sub-Panamax, etc. Vessel characteristics such as LOA, beam, and draft must be expressed in feet. Sailing speeds must be expressed in nautical miles per hour, or knots.

3.2.5.2 Vessel Operating Costs

Hourly vessel operating costs are defined for each vessel class based on the vessel status of "at sea" or "in port" and foreign or domestic flag. For each category, the operating costs are described with a triangular distribution. Corps field users may obtain vessel operating costs from IWR. Vessel operating costs are developed based on vessel speed, thus the two are directly associated. Note that vessel speed must be expressed in knots per hour. The user should take care to assure vessel operating costs and vessel sailing speeds are based upon consistent data and assumptions. The application of at sea or in port operating costs is determined by a set of algorithms defined in the model code, as follows:

- During reach transits and turning maneuvers, at sea costs are applied.
- In port costs are applied during dock visits, including time spent docking and undocking.
- Costs incurred during vessel delays at the dock are calculated based on a user-entered threshold time. If the delay is greater than the threshold time, at sea costs are used for the threshold time, with port costs for the remaining time. If the delay is less than the threshold time, at sea costs are used for the entire delay time. (See Section 5.1.2 for details on setting the thresholds in the Configuration Settings window.)
- A similar user-entered threshold value is used for facility nodes/turning areas. If the time spent at the facility node is less than the threshold, then at sea costs are applied, otherwise in port costs are applied to the time waiting.
- Delay time at the entrance point (bar only) are calculated based upon the delay duration; for delays less than two hours at sea costs are applied, in port costs are applied for delays of two hours or greater.
- In port costs are applied to all delays incurred at entry points.

Foreign and domestic operating costs can be assigned for each vessel class. HarborSym determines the appropriate costs to apply for each unique vessel movement based upon the vessel flag. Domestic costs are applied to "AMER" flagged vessels. Foreign costs are applied to all other flagged vessels, including the generic "Z_For" designation. If no flag is designated for a unique vessel, HarborSym applies foreign operating costs to movements made by that ship.

3.2.5.3 Vessel Size Units, Sailing Drafts, and Underkeel Clearance

Additional attributes which must be assigned at the vessel class level include vessel size units (VSU), sailing drafts, and underkeel clearance requirements. The VSU is an abstract concept that allows the user to provide a multi-dimensional accounting for vessel dimensions. The VSU is assigned at the vessel class level and is applied as a restriction at turning basins and docks. When assigning a VSU to a particular vessel class, users should consider operating practices that might limit the number or size of vessels that can simultaneously occupy docks, turning basins, and anchorages. As an example, a dock may have two cranes for loading and unloading vessels, thus having a user-defined VSU capacity of 2. If a vessel class, hypothetically called Class A, represents larger vessels that utilize both cranes during their dock visits, the VSU assigned should be 2. A smaller vessel class, Class B, may have a user-defined VSU of 1 if only one crane is occupied during a dock visit. Under this scenario, only one ship from Class A can visit the dock at a time, while up to two ships from Class B can utilize the dock simultaneously.

Minimum and maximum sailing drafts are assigned to each vessel class. HarborSym uses these values when determining vessel sailing drafts after commodity transfers. Considering the amount of cargo discharged or loaded at the dock and the unique vessel tons per inch immersion (TPI) factor, HarborSym calculates the vessel's outbound sailing draft. However, operating practices in the port may result in actual sailing drafts that do not match the straight numerical calculation (such as ballast adjustments or increasing bunkerage). HarborSym calculates the vessel sailing draft and applies the calculated value unless this value is below the class-based minimum or above the class-based maximum. Additional information on these procedures is available in Section 3.3.2, Draft Adjustments.

Underkeel clearance values, in feet, are required for each vessel class. In reaches with assigned underkeel clearance draft rules, HarborSym adds the mandatory class-based clearance value to the unique sailing draft to determine the minimum water depth necessary for the vessel to transit. For outbound movements, HarborSym considers the underkeel clearance requirement when setting the outbound sailing draft after commodity exchanges at a dock.

3.2.5.4 Priority Vessels

Vessel classes can be designated as "priority vessels". This function is intended to simulate the behavior of vessels that receive preferential treatment in harbors such that they are infrequently subjected to queuing delays. Typical vessel types falling into this category include cruise ships and LNG tankers. HarborSym gives a vessel priority by inserting it into the system well in advance of its actual arrival, such that subsequent vessels, when determining their possible passage through a leg, will take account of the priority vessel. In theory, a priority vessel can proceed through the system unimpeded and because HarborSym internally keeps track of future vessel arrival/departure times in each reach of a leg, it is possible to "pre-schedule" the priority vessel through all of its legs, in effect, requiring other vessels to take into account the presence of the priority vessel. To reach this outcome, HarborSym simulates the period of analysis twice for each simulation using priority vessels. The first run processes only the priority vessels, in essence, giving these ships free access to the channels and docks as they only face congestion effects with other priority vessels. The second run processes the priority vessels and all other vessels. In this second run, the non-priority vessels have advance knowledge of when priority vessels will require use of channels and docks, and face delays accordingly.

Due to the "pre-scheduling" approach applied in HarborSym, priority vessels may not process in the second run if they are deleted from the simulation (see Section 9.3 for additional information on deleted vessels). Vessels that do not complete their call because they remain in the system at the conclusion of the simulation period are termed "retained vessels" in HarborSym vernacular. To ensure all retained priority vessels are captured in the simulation of the full vessel call list, the user can direct HarborSym to extend the simulation period for the priority vessels only. All priority vessels that exit the system within the normal simulation period plus the extended simulation time are included in the second run. Statistics reported in the summary output reports will be accumulated only for vessels that complete their calls by the scenario specified duration. For example, if the extended time period is set to allow 10 extra days on an 800 hour simulation, the priority vessels run will process for 1040 hours, and all vessels that complete their calls within the 1040 hours will be available to the non-protocol run, but statistics on the vessels that complete after 800 hours will not be captured. The second run, simulating the full vessel call list, will process for the designated 800 hour simulation period.

3.2.6 Commodity Categories and Critical Commodities

Commodities are the cargo that is loaded and unloaded by the vessel at the harbor docks. Commodities are categorized by the user based upon the available manifest data. The user defines the units of measure for each commodity category (i.e., TEUs, tons, cars, passengers, etc.) and the tons per unit of measure. The user must also define the loading and unloading time at docks for each commodity category. Commodities with special handling protocols can be designated as "critical commodities", which allows the user to define rule based operating practices that must be observed for vessels carrying the specified commodities. After commodities are defined, the user establishes which vessel classes are able to carry which commodity categories.

Commodities can be classified as "critical" for the application of a commodity-specific transit restriction. Users can restrict meeting (passing or overtaking) of two vessels within a reach if either vessel is carrying a commodity designated as a "Critical Commodity". For this restriction to apply, at least one commodity carried on either vessel must be designated a critical commodity and the applicable rule must be established within the reach. Section 3.2.11 and Appendix B provide additional details on vessel transit rules.

3.2.7 Dock Visits and Commodity Transfers

Vessel calls, dock visits, and commodity transfers are each unique activities within HarborSym. A dock visit is one visit by a vessel to a dock. For vessel calls with multiple dock visits (intra-harbor movements), the user must specify the order in which each dock is visited. A commodity transfer is the loading or unloading of one commodity from one vessel during a dock visit. Transfers of multiple commodities types at a single dock are not numbered or ordered.

The vessel time at a dock is calculated as the sum of the vessel docking time, the total commodity transfer time, and the vessel undocking time. The user provides minimum and maximum docking and undocking times, by combination of vessel class and individual dock, from which a random number representing each of the docking and undocking times is generated. The commodity transfer is calculated based on user defined triangular distributions (minimum, most likely, and maximum values) for the combination of vessel type, dock, and commodity. Note that total commodity transfer time is additive for each commodity that is transferred – HarborSym does not provide for simultaneous processing of two or more commodity transfers. HarborSym also captures and records time vessels spend at the dock in a "wait" status due to system conflicts.

3.2.8 Vessel Route Groups

Economic analysis of channel deepening alternatives requires additional information for each vessel call, specifying the ocean sailing distance to be assigned to the call. HarborSym uses the concept of "route groups" as an alternative to directly specifying this distance for each vessel call. A route group is a named itinerary or portion thereof that a vessel may travel before and after visiting the port under study. Itineraries can be defined generally by larger geographic areas or more specifically when individual ports are known. If exact port-to-port itineraries are known, then the distance can be fixed, otherwise, a triangular distribution of distances can be specified. An appropriate usage of distributions would be, for example, if the exact port in Western Europe is not known or may vary.

Each vessel call must be associated with a Route Group. When the exact Route Group for a vessel call is known, this information should be specified in the Port Traffic Template, see Section 6.6 for additional details. HarborSym allows the user to define a default Route Group for each vessel class and designate the percentage of vessels within the vessel class traversing a given Route Group. During the

Port Traffic import, calls with unknown Route Groups are assigned to a Route Group given these percentages. Thus, the exact assignment of sea distance to individual calls is not strictly necessary because costs (in port and at sea) are associated with a vessel class and sea distance is associated with a Route Group. This allowance is applicable as long as the overall assignments to the class are reflective of the distribution of distances traveled by vessels of that class. For each Route Group the user must assign minimum, most likely, and maximum distances between the study port and the prior and next ports of call. In addition, these parameters must be specified for an additional sea distance to cover additional ocean sailing distances not covered by the prior and next ports of call. All Route Group distances must be entered in nautical miles.

HarborSym uses these distributions to separately generate the three distances (prior port, next port, and additional) for each vessel call and, consequently, a total cost at sea. The total hours at sea are established by determining the total sea distance (prior port distance + next port distance+ additional sea distance) divided by the vessel speed. Vessel speed is calculated based on a user defined distribution of knots, or nautical miles per hour. The vessel cost at sea, which is entered as cost per hour, is multiplied by total at sea hours to generate the total at sea cost.

The limiting depth for the prior and next port of call must be specified for each Route Group. Limiting depth for the prior and next port is not used directly by HarborSym. Rather, prior and next port limiting depth is utilized in the CLT, a module developed to assist the user in generating a future call list for containerships that is linked to the HarborSym IDB. Next port is used by the CLT to determine the amount of cargo that can be loaded on a containership traversing a given route. Prior port limiting depth is used in by the CLT to determine how fully laden a vessel traversing a given route enters the port of study. This feature prevents creation of a vessel call list with vessels loading or unloading cargo at the study port that is in excess of the physical constraints at other ports in the route. User's should follow Corps guidance on the assumed depth for prior and next ports within a Route Group for the with-project condition, considering the future expansion of the Panama Canal.

Knowledge of a vessels' ocean journey is not necessary to complete a channel widening study. If the at sea mileage will not impact the study results, these parameters can be set to 1. If using HarborSym to simulate a widening study not impacted by vessel routes, the prior and next port limiting depths should be set to a value higher than the study port limiting depth.

To aid planners in collecting and analyzing the data necessary to populate Route Groups for a given study area, IWR developed the Automatic Identification System Data Analysis and Pre-Processor (A-DAPP). The A-DAPP provides the capability to visualize, analyze, and synthesize historical Automatic Identification System (AIS) data for use in container port channel improvement studies and associated simulation modeling. During the model processing, the A-DAPP analyzes a vessel's ping as well as the vessel characteristics and port information to identify the Route Groups, Services, and Arrival Draft details for a vessel call, among other capabilities. Within the A-DAPP context, a Route Group name is provided that indicates the prior port, next port, and additional regions visited. For more information on the A-DAPP, please refer to the A-DAPP User's Guide.

3.2.9 Vessel Movement Behavior

Vessel trips in HarborSym begin when a vessel "arrives" at a user-defined system entry point according to the arrival time in the vessel call list. HarborSym calculates the vessel's journey within the port based upon the destination docks, transit speeds, and system conflicts.

3.2.9.1 Legs

HarborSym simulates the movement of vessels through the system based upon specific user defined information. Vessel calls are defined by the vessel physical characteristics, the time the vessel arrives in the system, the destination dock or docks, and the commodities transferred at each location. Relevant physical characteristics of the harbor, including elements such as vessel speeds in reaches, commodity transfer rates, and turning basin usage, are also provided by the user.

Each complete vessel call (voyage from entry to destination dock(s) through to exit and ocean voyage) is considered to be composed of a set of "legs." A leg is a contiguous set of reaches between stopping points. HarborSym assumes that a deep-draft vessel cannot stop except at docks or anchorages. The legs of the vessel call are thus the sets of reaches from the entrance to the first dock (Leg 1), from the first dock to the second dock (Leg 2), etc. and from the final dock to the exit (Leg n). Transit rules are checked as a vessel prepares to enter a leg (e.g., upon arrival at the entrance or departure from a dock), based on the scheduled movements of all other vessels that have already entered (or, in the case of priority vessels, will enter) the system. A vessel can only start moving within a leg when no transit rule restrictions are activated for any of the reaches in the leg. A key assumption of the simulation is that once a vessel is moving within a leg, it has priority over all other vessels that subsequently enter the leg. If rule restrictions are activated, the vessel must wait at the entry, dock, or anchorage, until the rule restriction situation no longer exists, at which time the vessel can enter the leg.

Once a vessel reaches a stopping point in the system, HarborSym calculates the amount of time spent at the location based upon the activities to be completed (i.e., docking and undocking, and commodity transfers) and delays due to system conflicts restricting departure. When the next leg of the vessel's trip is free of conflicts, the vessel proceeds. Under certain conditions, vessels can proceed part way through a leg to reach an anchorage, where they can wait until they can complete the leg, checking the transit rules for the remainder of the leg at user-defined intervals to see if they can proceed. HarborSym will automatically direct vessels to an available anchorage within the vessels desired route if the capability is activated for the simulation. Note that a turning area is not considered an intermediate stopping point – the time spent in a turning area is accounted for in the initial testing of potential conflicts within the leg, and a vessel leaves a turning area at its scheduled time without additional testing of transit rules for the remainder of the leg.

The ocean sailing voyage leg of a vessel call is not subjected to rule testing. For each route group the user provides statistics on the distance between the study port and prior/ next ports of call in the vessel's voyage, as well as any additional sea distance traveled on the voyage. From these distributions specific distances are assigned to each vessel call, which are added to the in-port portion of the vessel voyage.

3.2.9.2 Vessel Path

Several of the HarborSym outputs, as described in Appendix C, report a "path" for each individual vessel call. This describes the series of legs a vessel travels during a call to the port, including intermediate nodes. Such a vessel path might report the entrance node, the turning basin used, the docks visited, and the exit node. Anchorages are not yet incorporated into the path.

3.2.9.3 Speed in Reach and Reach Transit Time

The reach transit time is the time a vessel takes to traverse a reach from starting node to ending node. Transit time of a vessel through a reach is determined based on the reach length, and the vessel class

specific sailing speed. In each reach, the sailing speeds are assigned for vessel classes based upon the cargo status of light or loaded. HarborSym determines which speed to apply (light or loaded) based upon the relative commodity quantities onboard during the vessel's inbound and outbound movements. If the sum of all the commodity transfers for the call is a net import to the port, then the vessel is assumed to be loaded at arrival; conversely, if the sum of commodity transfers is a net export from the port, the vessel is assumed to be light on arrival. The vessel status is switched at the first dock at which the commodity transfer at that dock is consistent with the net behavior. For example, if the vessel call is a net export call, then the vessel arrives light, but will switch status at the first dock at which there are net export commodity transfers (adding loading to the vessel). Improvements to the harbor may decrease reach transit times by increasing the average speed of vessels in the reach.

3.2.9.4 Vessel Passing and Overtaking

To mimic real world behavior, HarborSym allows vessels to overtake and pass other ships within the system unless the behavior is restricted by the user through a transit rule. Overtaking refers to two vessels moving in the same direction in a channel reach. A vessel traveling at a faster speed may move in front of, or overtake, a vessel moving more slowly through the channel segment. In HarborSym terminology, passing refers to the bi-directional movement of two vessels within a reach. The default setting in HarborSym permits inbound and outbound vessels to travel simultaneously through the channel. The umbrella term, "meeting", refers to both passing and overtaking. No meeting would mean no passing or overtaking. No overtaking implies that passing is not allowed where both vessels are going in the same direction. No passing restricts vessel movement not allowing passing when vessels are going in opposite directions.

3.2.9.5 Intra-Harbor Movements

Within HarborSym, vessels are permitted to make multiple dock visits. When ships visit multiple docks within a single vessel call, the user must define the order in which the docks will be visited and provide specific commodity transfer quantities at each location. With this information, HarborSym calculates a "dock to dock" leg, where the vessel may be forced to wait at the first dock if system conditions prevent its free transit to the next dock on its route. In the current model framework, vessels visiting multiple docks during one vessel call will turn in the turning basin associated with each dock of their voyage. The model does not currently have the capability to eliminate turning basin visits in-between multiple dock visits. The present version of the model allows for a maximum of 5 dock visits for a call.

3.2.10 Elements of Variability

HarborSym is a Monte Carlo simulation model with variability incorporated into specific elements of the system. These include:

- Vessel Arrival Time: the vessel call list imported into HarborSym or manually created in the user interface provides a specific arrival date and time for each vessel calling the system. When multiple iterations are simulated using the same call list, HarborSym perturbs the arrival date and time of each call between iterations. This is accomplished by adding a random fraction of a day to the stored arrival date / time. The perturbation is only additive; the arrival date / time for iterations after iteration #1 are never less than the user provided schedule.

- Vessel Operating Costs: the vessel operating costs for each vessel call are drawn from a triangular distribution. The minimum, most likely, and maximum operating costs are populated at the vessel class level.

- Turning Time: the time vessels spend executing turning maneuvers is drawn from a triangular distribution. The minimum, most likely, and maximum turning times are populated for each turning area.
- Vessel Docking Time: the time vessels spend docking and undocking is drawn from a uniform distribution. The minimum and maximum docking / undocking times are populated for each dock – vessel class combination.
- Commodity Transfer Rates: the time required to load and unload commodities is drawn from a triangular distribution of units per hour. The minimum, most likely, and maximum loading / unloading times are populated for each dock – vessel type – commodity category combination.
- Speed at Sea: the vessel sailing speed at sea for each vessel call is drawn from a triangular distribution. The minimum, most likely, and maximum sailing speeds at sea are populated at the vessel class level. Expressed in knots, or nautical miles per hour.
- At Sea Distances: as discussed in Section 3.2.8, distances between the study port and prior/ next ports of call, as well as any additional at sea distances, are entered as triangular distributions for each Route Group. Expressed in nautical miles.

3.2.11 Vessel Transit Rules

The default condition in HarborSym allows all vessels to move through the system without any restrictions, including the freedom to operate beyond set channel dimensions. Such operations allow the users to estimate the traffic flow and associated transportation costs in a completely unrestricted system. However, to better approximate the realities of vessel operations in a harbor, HarborSym includes transit rules to limit vessel movements. The user assigns transit rules to reaches of the network from a menu of pre-defined rules. Rules are defined in terms of the type of rule (e.g., no vessel movement, no passing), applicable condition (day, night, any time), and vessel-specific parameters that characterize the rule's application (e.g., beam, draft, length overall). For example, a rule may state that two vessels may not pass at night in a given reach if their combined beam width exceeds 250 feet (76.2 meters). Other rules within the model relate to vessel movement under maximum current conditions or specific draft limitations. Capacity limits can also be specified for docks, turning basins and anchorages/moorings.

The rules currently implemented are based on procedures of pilots in specific ports. However, the rules are generic, such that users parameterize the application by specifying the applicable conditions and vessel physical characteristics that apply to a given reach. This approach allows the model to be portable between many study areas, although it is understood that all possible transit rules may not be incorporated into the existing model framework. All rules currently implemented are discussed in detail in Appendix B.

Vessel traffic rules impact harbor traffic by potentially delaying a vessel's transit through a reach while it waits for harbor conditions to change or for another vessel to leave the reach. Vessels already transiting the system are given the right-of-way, such that vessels testing reach availability will be delayed if another vessel is already scheduled to occupy the reach and the simultaneous usage by both ships would create a conflict.

The rules within HarborSym can be generalized into several broad categories of delay, as outlined in Table 2. Evaluating output based upon these general groupings can assist the user in determining the

primary causes of delay within the system. It should be noted, however, that often a single delay can be caused by multiple rule triggers in many reaches simultaneously. HarborSym reports all triggers to present a complete picture of the system conflicts.

Table 2: HarborSym Traffic Rule Wait Cause Categories

Cause	Association	Abbreviation in Output
Vessel Size Constraint	Rule	VSC
Congestion	Rule	C
Buffer Zone	Rule	BZ
Critical Commodity	Rule	CC
Tide	Rule	T
Anchorage VSU Constraint	Anchorage Usage	AVSU
Anchorage Number of Vessels Constraint	Anchorage Usage	AVN
Anchorage Depth Constraint	Anchorage Usage	AVD
Turning Area Number of Vessels Constraint	Turning Area Usage	TAVN
Turning Area Depth Constraint	Turning Area Usage	TAD
Turning Area VSU Constraint	Turning Area Usage	TAVSU
Dock VSU Constraint	Dock Usage	DVSU
Dock Number of Vessels Constraint	Dock Usage	DVN

HarborSym includes two families of transit rules, single vessel and multiple vessel, as described below. Single Vessel Rules involve only one vessel and the appropriate vessel parameters are entered only for the "moving vessel." An example single vessel rule restricts sailing at night when a vessel exceeds a set size threshold (e.g., capacity limitations). Another typical single vessel rule is a sailing draft restriction, which will prohibit vessels drafting greater than a user defined value from transiting a specific reach.

Multiple Vessel Rules involve encounters between two vessels. Parameters must be entered for the "moving vessel" and the "other vessel." An example of a multiple vessel rule is a rule that no vessel over a size threshold may encounter (overtake or pass) a priority vessel.

Individual transit rules can be applied port-wide, such that the exact restriction applies in all reaches. For example, if overtaking is not permissible in any section of the harbor, this can be set as a port transit rule rather than entering the rule in every reach. Caution should be taken when adding port level transit rules, as they apply to all reaches throughout the system and all projects within a study. Therefore, active port level transit rules will enforce the restriction universally in all projects, which may not be accurate if a future condition will alleviate the need for such a restriction (such as a channel widening alternative under which overtaking is permissible).

Note that HarborSym does not enforce any "logical" restrictions in the absence of activated rules – in an actual harbor, vessels are not physically able to transit a reach if their draft requirements are greater than the reach draft. In HarborSym, however, this restriction is not applied unless the appropriate rule is made active for the reach.

3.2.12 Safety Zones

A safety zone is similar to placing a bubble around a vessel as it moves. The distance extends from the ship's bow and the ship's stern, as shown in Figure 2. The safety distance, designated by the user, is

equal for both sides. No moving vessels are allowed next to the designated safety vessel. Safety zones are user-defined characteristics specific to the commodity. [A "safe distance" rule provides a similar capability but is independent of the commodity being carried.] The user defined characteristics describe how the model should treat vessels carrying these commodities. Additional details on the application of safety zones within HarborSym are available in Section 6.10.

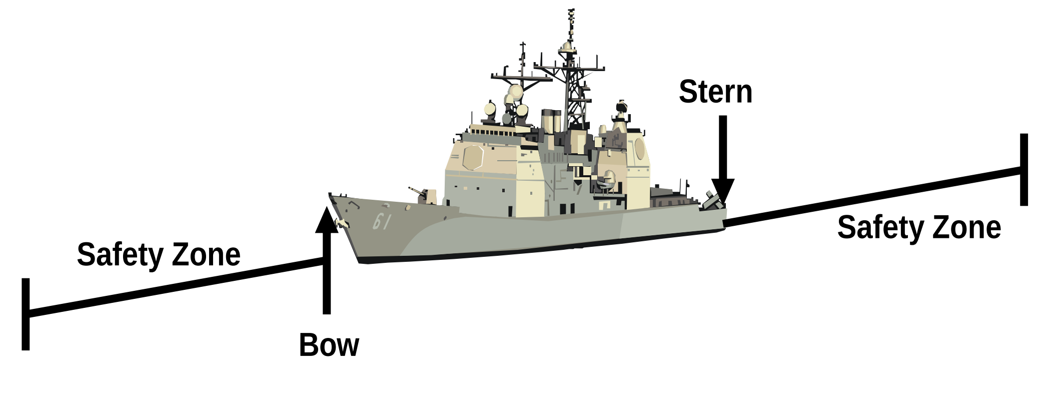

Figure 2: Safety Zones

Local, state, and national agencies set guidelines that require safe passage of certain commodities such as Liquefied Natural Gas (LNG), Liquefied Petroleum Gas (LPG), Anhydrous Ammonium (NH_3) and other potentially hazardous commodities. Safety zones represent these vessel movements in the harbor. Vessels carrying hazardous commodities require a greater distance from other ships to ensure safe passage. HarborSym users designate commodities requiring safety zones, zone size, when and where zones are active. Vessels carrying the designated commodity are triggered to have safety zones no matter the amount carried.

HarborSym recognizes commodities rather than specific vessels to trigger safety zones. However, vessels may enter port with a safety commodity and exit the port with none, and vice versa. HarborSym allows the user to specify both legs or the one leg with the commodity to have active safety zones. Safety zone rules can be designated to apply only when a vessel is carrying the sensitive commodity or during the entire voyage of a vessel that carries the commodity for only a portion of its trip. For example, if LNG is exported from a study area and treated as a safety zone commodity, a LNG tanker may arrive at the port carrying no LNG and load some quantity at the dock. Users can designate safety zone rules to apply only to the outbound movement when the vessel carries LNG or for both the inbound and outbound legs, regardless of the amount of cargo carried during either segment. Users will determine this model setting based on port rules and other guidelines.

HarborSym allows the user to activate all harbor reaches or specific reaches to have safety zones applied. Safety zones are examined for rule violations when vessels carrying designated commodities enter the reaches where the safety zone is marked active and a safety zone rule exists. Reaches without safety zones will treat vessels carrying designated commodities the same as all other vessels.

3.2.13 Rule Violations / Triggers

Rule violations are determined when a leg is checked prior to vessel entry. If a rule trigger or activation occurs, then the testing vessel cannot proceed directly to its destination in the leg. It must

instead either delay traveling or proceed as far as possible to an available anchorage, waiting there until it can attempt to continue the journey. HarborSym does not allow a rule violation to occur, but maintains a file of all events in which a rule was triggered and prevented vessel transit. Additional information on the model processing logic, including how rule triggers are implemented, is included in Section 3.3 Model Behavior.

3.2.14 Tide and Current Modeling

Whenever there is a predictable water depth greater than the channel controlling depth, the additional depth is likely to be used in the operations of the deepest drafting vessels calling the port. The additional water depth can allow vessels to enter the system that would otherwise be prevented due to insufficient controlling depth. Use of tides may involve vessel delay costs that can be impacted by physical modifications to the navigation channels. In order to simulate these conditions, HarborSym requires information on the applicable tide levels at the study port.

Tide prediction is needed for HarborSym because of tide-related rules. Typical tidal rules relate to single vessel movements, limited by depth or current. A typical current rule would restrict sailing if vessel draft is greater than a certain amount while current exceeds a specified amount. A depth rule limits sailing based on “maximum draft plus tide”, i.e., a vessel cannot move in a channel unless the draft plus the current tidal depth is greater than some value. Thus, tide prediction is required for both current and tide height.

HarborSym utilizes the tide prediction engine WTides developed by Philip Thornton (http://www.mdr.co.nz/) to estimate astronomical tide height and current levels. These are the same values commonly published in tide tables, but are not the meteorological tide or current values that may be influenced by storms. Tide and current are predicted and stored for user selected tidal stations for the study area in one-hour increments for the duration of the simulation. Tide reference stations are identified separately from current reference stations. Up to two tide stations are specified for each reach, with a user defined weighting value (between 0 and 1) assigned to determine the contribution of each tidal station to the reach. The interpolation provides an estimate of the water depth and current velocity throughout the reach during the simulation; within HarborSym, tide or current values do not vary along the length of a reach. Note that tide/current values are predicted only for reaches, not for nodes – values for nodes are derived from the value calculated for the reach. Note also that unless reference stations and interpolation values are properly selected for reaches, it is possible to get different tidal prediction at a node, depending upon which reach is used for the tide calculation. Additional detail on setting tide stations in HarborSym is described in Section 6.8.

Currently, HarborSym does not include the capability for users to identify secondary tidal stations not included in the WTides database. If only one reference point is identified within the study and an interpolation value of 1 is entered for all reaches, all nodes and reaches will have uniform water depth and current velocity. The IWR Tide Tool, a separate, standalone model, is capable of generating secondary tide stations for import into HarborSym. The IWR Tide Tool User’s Manual provides instruction on how to integrate the outputs into a HarborSym study.

3.2.15 Scenario

A scenario is the set of defined run parameters that specify the conditions of a simulation. Scenarios have names and are retained for future reference. The same scenario can be used for simulations of vessel traffic on multiple projects.

3.2.15.1 Simulation Duration and Start Date

The model simulates vessel traffic starting at midnight on the start date and continuing for the duration specified by the user. The duration is specified in hours (all time in the model is in hours). Only one simulation period can be specified in a scenario. The user can specify any simulation period within a year, an entire year, or longer. Note that only arrival dates within the vessel call list that fall within the simulation period are processed, so appropriate correspondence between the scenario specification of start date and duration and the values in the vessel call list is necessary.

3.2.15.2 Number of Iterations

A Monte Carlo simulation consists of multiple iterations of vessel traffic flow during the same time period. Statistics are developed from the multiple iterations of the simulation. One iteration of a simulation is one duration period starting at the scenario start date. The different parameters affecting vessels transit (commodity transfers, docking time, etc.) vary between iterations within the input range set by the user. The user specifies the number of iterations of the simulation to be carried out when defining the scenario, based upon the need for accuracy. As the number of iterations increases, the stability of the simulation output should increase. The optimal number of iterations will vary by study area depending upon the degree of variability in the user defined parameters. Evaluating the output reports will provide insight into the model stability. Depending upon the specific conditions at a given study area, users may consider running first 100, then 500, then 1,000 iterations to evaluate the variability in outputs and determine the optimal number of iterations for use throughout the evaluation.

For initial testing of the vessel call list and input data viability, only a single iteration of the simulation is typically necessary.

Note that when using the BLT and/or CLT to develop a future synthetic vessel call list, either a single iteration or multiple iteration VCDB can be generated. If a multiple iteration VCDB is generated, then HarborSym will loop through the iterations when running a simulation. For example, if 5 iterations were generated with the BLT/CLT and 100 iterations are specified for a HarborSym simulation, then HarborSym will pull iterations 1-5 from the BLT/CLT-generated VCDB for iterations 1-5, then 1-5 for iterations 5-10 and so on.

3.2.15.3 Wait Times Before Retry

To prevent a rule violation, the moving vessel must wait if proceeding will cause a conflict in any reach of its leg. The length of time the vessel must wait before a retry (attempt to move) is defined by the user. The wait time is defined in fractions of an hour. HarborSym queries the system in the user defined interval to determine if the conflict has cleared and the vessel is able to proceed. Providing more refined values for wait time before retry (i.e., 5 minutes) will allow HarborSym to recognize that the conflict has dissipated more immediately and prevent incorrect assignment of vessel delays. However, in a highly congested system, requiring the system to check its status at frequent intervals may greatly increase the processing time. Users should evaluate the system conditions and determine the optimal value. An initial value of 0.25 hours for each of the wait increments has been used with success.

Different wait times can be entered for three types of locations where vessels wait: the entry, the docks, and anchorages.

3.3 Model Behavior

HarborSym is an event driven model. Vessel calls are processed individually and the interactions with other vessels are taken into account. For each iteration, the vessel calls for an iteration that fall within the simulation period are accumulated and placed in a queue based on arrival time. When a vessel arrives at the port, the route to all of the docks in the vessel call is determined. This route is comprised of discrete legs (contiguous sets of reaches, from the entry to the dock, from a dock to another dock, and from the final dock to the exit). The vessel attempts to move along the initial leg of the route. Potential conflicts with other vessels that have previously entered the system are evaluated according to the user-defined set of rules for each reach within the current leg, based on information maintained by the simulation as to the current and projected future state of each reach. If a rule activation occurs, the arriving vessel must either delay entry or proceed as far as possible to an available anchorage, waiting there until it can attempt to continue the journey. [The ability to allow or disallow use of intermediate anchorages can be controlled globally for the simulation by a data parameter in the run scenario. Additional detail is available in Section 3.2.15]. Vessels move from reach to reach, eventually arriving at the dock that is the terminus of the leg.

After the cargo exchange calculations are completed and the time the vessel spends at the dock has been determined, the vessel attempts to exit the dock, starting a new leg of the vessel call; rules for moving to the next destination (another dock or an exit of the harbor) are checked in a similar manner to the rule checking on arrival, before it is determined that the vessel can proceed on the next leg. As with the entry into the system, the vessel may need to delay departure and re-try at a later time to avoid rule violations and, similarly, the waiting time at the dock is recorded.

A vessel encountering rule conflicts that would prevent it from completely traversing a leg may be able to move partially along the leg, to an anchorage or mooring. If so, and if the vessel can use the anchorage (which may be impossible due to size constraints or the fact that the anchorage is filled by other vessels), then HarborSym will direct the vessel to proceed along the leg to the anchorage, where it will stay and attempt to depart periodically, until it can do so without causing rule conflicts in the remainder of the leg. The determination of the total time a vessel spends within the system is the summation of time waiting at entry, time transiting the reaches, time turning, time transferring cargo, and time waiting at docks or anchorages. HarborSym collects and reports statistics on individual vessel movements, including time in system, as well as overall summations for all movements in an iteration.

3.3.1 HarborSym Deepening Cost Allocation Calculations

HarborSym was initially developed as a tool for analyzing channel widening projects, which were oriented toward determining time savings or vessels transiting a harbor. It did not allow for assessing changes in vessel loading or in shipping patterns. The most recent release of HarborSym was designed to assist analysts in evaluating channel deepening projects, in addition to the original model capabilities. The deepening features consider fleet and loading changes, as well as incorporating calculations for both within harbor costs and costs associated with ocean voyage. The goal of the deepening version is to assist the user in evaluating the effects of proposed channel deepening in terms of transportation cost savings for various alternatives. While overall (port level) information is of primary interest, more detailed information can be associated with vessel classes, commodities and individual vessel calls, may also be of interest. Allocation calculations, carried out at the vessel call level, are the key to this procedure.

Each vessel call has a known (calculated) associated cost, based on time spent in the harbor and ocean voyage and cost per hour. Also for each vessel call, the total quantity of commodity transferred to the port (both import and export) is known, in terms of commodity category, quantity, tonnage and value. The basic problem is to allocate the total cost of the call to the various commodity transfers that are made.

Each vessel call may have multiple dock visits and multiple commodity transfers at each visit, but each commodity transfer record refers to a single commodity and specifies the import and export tonnage. Also, at the commodity level, the "tons per unit" for the commodity is known, so that each commodity transfer can be associated with an export and import tonnage. As noted above, the process is greatly simplified if all commodity transfers within a call are for categories that are measured in the same unit, but that need not be the case.

When a vessel leaves the system, the total tonnage, export tonnage, and import tonnage transferred by the call are available, as is the total cost of the call. The cost per ton can be calculated at the call level (divide total cost by respective total of tonnage). Once these values are available, it is possible to cycle through all of the commodity transfers for the vessel call. Each commodity transfer for a call is associated with a single vessel class and unit of measure. Multiplying the tons or value in the transfer by the appropriate per ton cost, the cost totals by class and unit for the iteration can be incremented. In this fashion, the total cost of each vessel call is allocated proportionately to the units of measure that are carried by the call, both on a tonnage and a value basis. Note that this approach does not require that each class or call carry only a commensurate unit of measure.

The model calculates import and export tons, import and export value, and import and export allocated cost. This information allows for the calculation of total tons and total cost, allowing for the derivation of the desired metrics at the class and total level. The model can thus deliver a high level of detail on individual vessel, class, and commodity level totals and costs.

Either all or a portion of the at-sea costs are associated with the subject port, depending on whether the vessel call is a partial or full load. The at-sea cost allocation procedure is implemented within the HarborSym kernel and utilizes the estimate total trip cargo (ETTC) field from the vessel call information along with import tonnage and export tonnage. In all cases the ETTC is the user's best estimate of total trip cargo. Within the BLT and CLT, the ETTC field is estimated as cargo on board the vessel at arrival plus cargo on board the vessel at departure, in tons. ETTC can also be expressed as:

$$\text{ETTC} = 2*\text{Cargo on Board at Arrival} - \text{Import tons} + \text{Export tons}$$

There is a basic algorithm implemented to determine the fraction of at-sea costs to be allocated to the subject port. First, if ETTC for a vessel call is equal to zero or null, then none of the at-sea costs are associated with the port. The algorithm then checks if import or export tons are zero for a vessel call. If either are zero, then the following equation is applied to determine the at-sea cost allocation fraction associated with the subject port:

$$\text{At-Sea Cost Allocation Fraction} = (\text{Import tons} + \text{Export tons})/\text{ETTC}$$

Finally, when both import and export tons are greater than zero, the following equation is applied to determine the at-sea cost allocation fraction associated with the subject port:

$$\begin{aligned}\text{At-Sea Cost Allocation Fraction} = {} & 0.5 * (\text{Import tons}/\text{Tonnage on board at arrival}) \\ & + 0.5 * (\text{Export tons}/\text{Tonnage on board at departure})\end{aligned}$$

Where:

Tonnage on board at arrival = (ETTC + Imports – Exports)/2

Tonnage on board at departure = Tonnage on board at arrival – Imports + Exports

For user crafted vessel call lists that are imported into HarborSym, care must be taken to properly populate the ETTC field. The BLT and CLT modules will populate the ETTC field. Note, however, that the BLT populates the field in a fashion that assumes for all vessel calls the at-sea cost allocation fraction is 1. If the user knows that bulk vessels are carrying cargo loaded at another port not destined for the subject port, the ETTC field should be manually adjusted accordingly. Also note that if the user desires for all at-sea costs to be allocated to the port, then ETTC for a given vessel call should be expressed as import tons + export tons.

Analysts face the difficult issue of generating vessel call lists that represent fleet arrivals and loadings under future without- and with-project conditions. That is, a with-project vessel call list must represent the future fleet and commodity demands for import and export at the port, and the associated commodity transfers and vessel loadings must be reflective of the possibilities offered by the deepened channels. Generation of these vessel call lists is the role of the HarborSym BLT, CLT, and Combiner modules. The modules are designed to generate a vessel call list that can be run through HarborSym, based on user provided information on the fleet and channel constraints as well as commodity demands, for general bulk and containerized vessels. Additional information on these modules can be found in Section 4

3.3.2 Draft Adjustments

On arrival at a dock, the quantity of commodity transferred is used, in conjunction with the vessel TPI, to calculate the departure draft based on the arrival draft. Draft on departure from the dock is important in the process of checking the leg to determine if the vessel can proceed. In the HarborSym database the arrival draft at the bar is the starting point for these calculations. Given the manner in which the vessel call database may be constructed (from a variety of data sources and assumptions), and the fact that behavior such as ballasting and bunkering is not accounted for in the model, it is possible for the simple draft adjustment calculation based on TPI and commodity transfer to lead to departure drafts that, in conjunction with transit rules, preclude the vessel from departing the dock. Accordingly, provision is made within HarborSym for a process that adjusts the outbound draft, if necessary, to place it within a reasonable range so that the vessel can proceed. The maximum draft that can traverse the next leg, based on underkeel clearance and tide, is calculated and compared with the draft calculated on commodity transfers. Adjustments are made to the departure draft if needed, taking into account user-defined vessel class maximum and minimum drafts. In this fashion, vessels do not “get stuck” while attempting to depart a dock after transferring commodities. The user is informed of any such automatic adjustments in an output file.

3.4 HarborSym User Interface

When selecting View/Study Explorer from the HarborSym main menu, three panes are visible to the user; the Graphics Pane, the Navigation Pane, and the Data Entry Pane, as shown in Figure 3. Together these structures provide the user with a user interface (UI) that supports data entry and visualization. This structure presents the user with a visual representation of the study area, detailed information on a single data element, and the relative positioning of the element within the structural hierarchy.

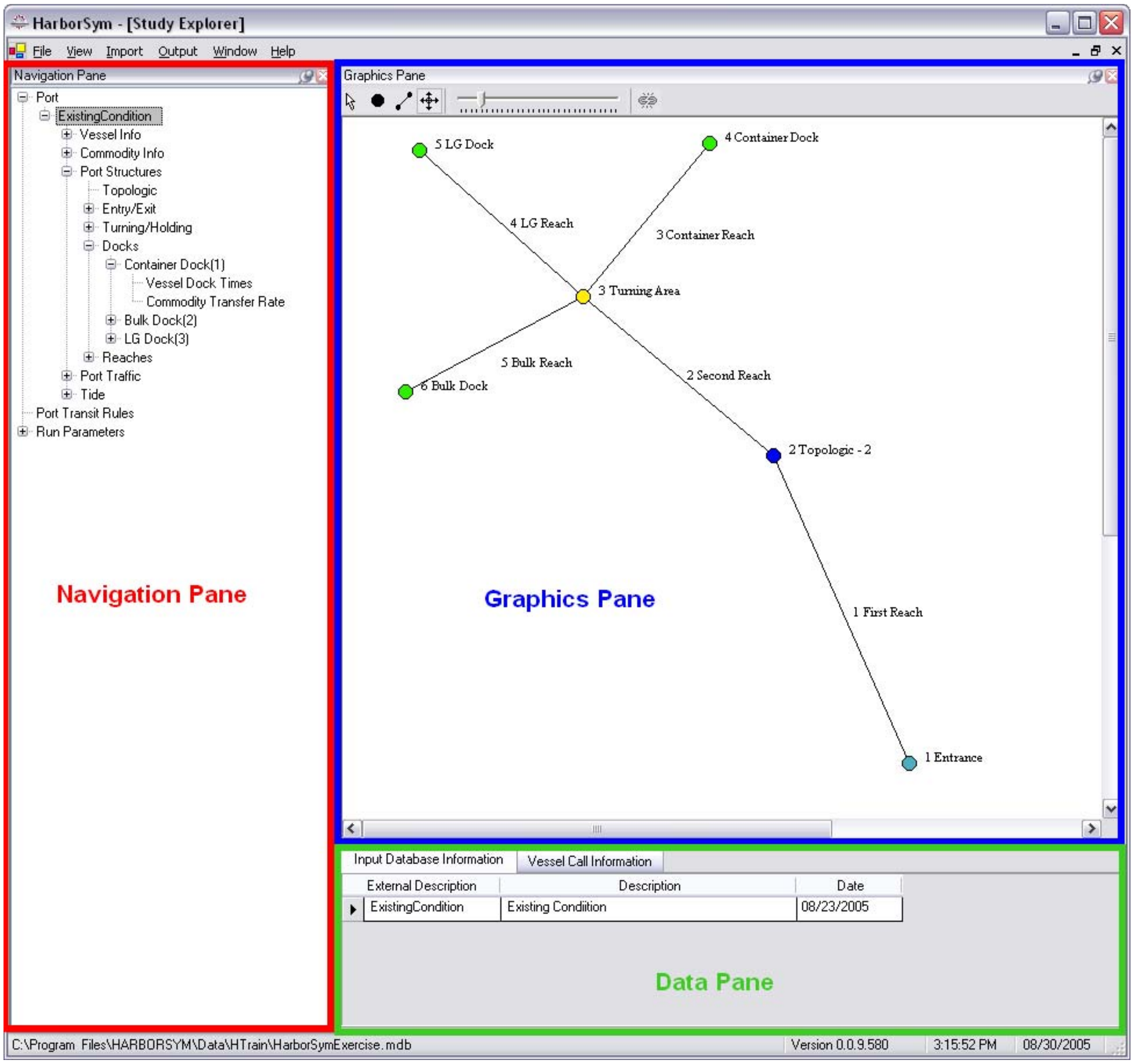

Figure 3: HarborSym Study Explorer

The relative sizes of the three panes can be modified by the user by moving the borders between the panes. The three panes are linked, as shown in Figure 4.

The Graphics Pane provides a visual representation of the harbor and can be used to draw and define the topological features. The Navigation Pane contains a hierarchical listing of project components and is primarily used to call up the data entry grids in the Data Entry Pane. The Data Entry Pane contains the data entry grids for the user to view and input data. The three panes are linked through the interface and show related information. For example, when a user selects a dock in the Navigation Pane, that dock is highlighted in the Graphics Pane. The Data Entry Pane automatically navigates to the dock grid, highlighting the row with data associated with the selected dock.

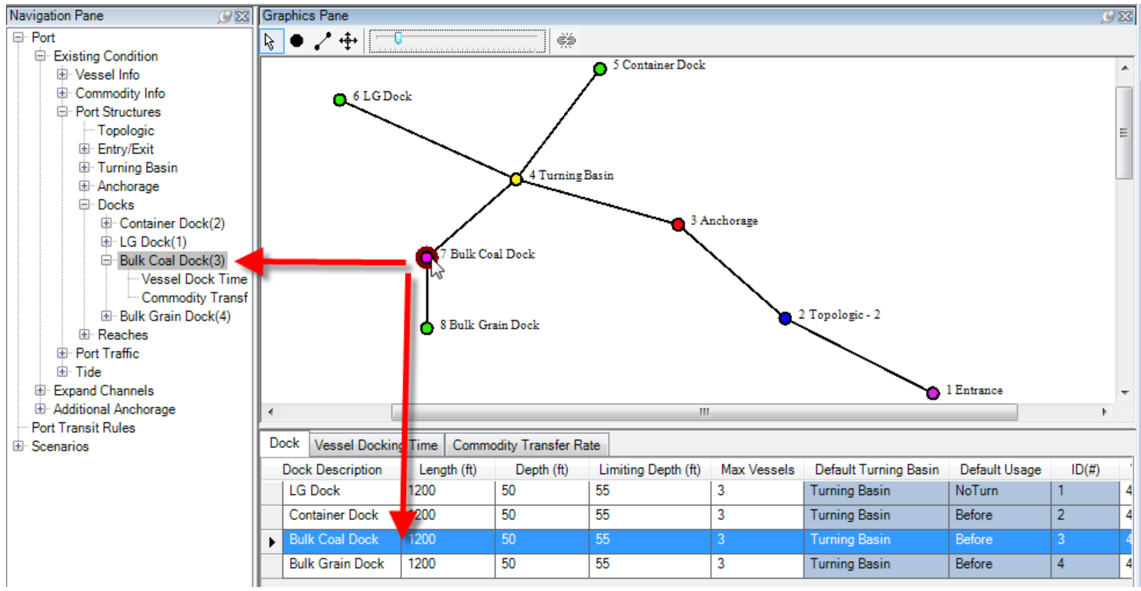

Figure 4: Three Pane Linkage

3.4.1 Graphics Pane

The Graphics Pane shows the node network developed by the user, which is a visual representation of the harbor, as shown in Figure 5. The node network represents a project using nodes and reaches. Nodes are points that represent an entry/exit point, a turning area, an anchorage, a dock, or a topologic node indicating a change in channel conditions. The Graphics Pane is used to create the topological features of the study harbor. Additional information on creating a network with the Graphics Pane is presented in Section 6.2.

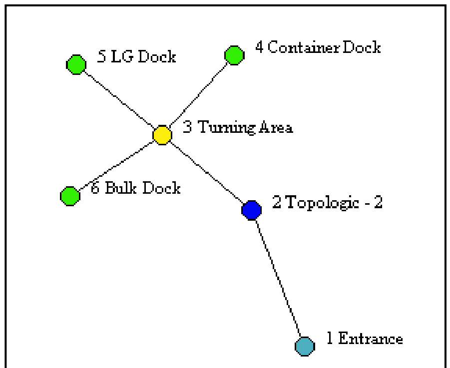

Figure 5: HarborSym Graphics Pane

3.4.2 Navigation Pane

Navigation Pane contains five hierarchical listings for each project; Vessel Info, Commodity Info, Port Structures, Port Traffic, and Tide. These listings are obtained by clicking on the plus icon to the left of the project name as shown in Figure 6. To the left of each of these listing is a plus icon, which can call the next level of detail. The plus icon to the left of Vessel Info will call the vessel types.

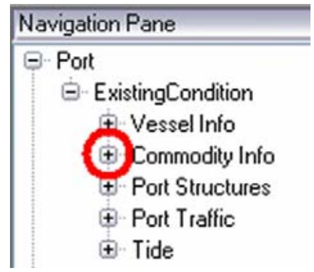

Figure 6: Navigation Pane

The plus icon to the left of Commodity Info will call up each of the commodity categories. The plus icon next to Vessel Info will call up information on Vessel Types and Route Groups. Likewise, the plus icon to the left of Port Structures will call up Entry/Exit, Turning Basins, Anchorage, Docks, Reaches, and the Dock/Turning basin Matrix. The plus icon to the left of Port Traffic will call up Unique Vessels, Vessel Calls, Dock Visits, and Commodity Transfers. This tree structure is shown in Figure 7.

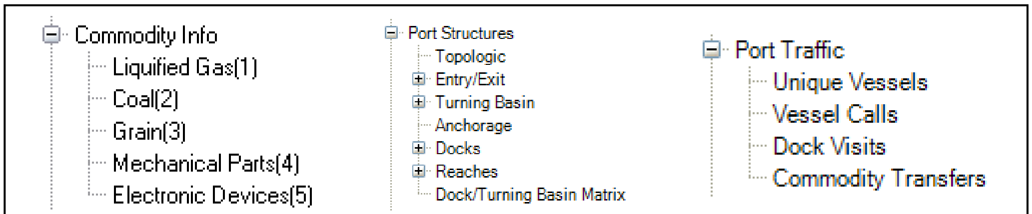

Figure 7: Navigation Pane Expanded

Two additional branches are visible on the Navigation Pane tree structure: "Port Transit Rules" and "Scenarios". Selecting Port Transit Rules will navigate to all rules that are applied to all reaches in the system. The plus icon to the left of Scenarios will reveal the established scenarios for processing simulations.

3.4.3 Data Entry Pane

The Data Entry Pane contains the data entry grids that are used to input data into HarborSym and view this data. The data entry grids are used primarily to enter the data associated with the selected tree node category. These forms have tabs at the top of the pane to call up additional associated data entry grids as shown in Figure 8.

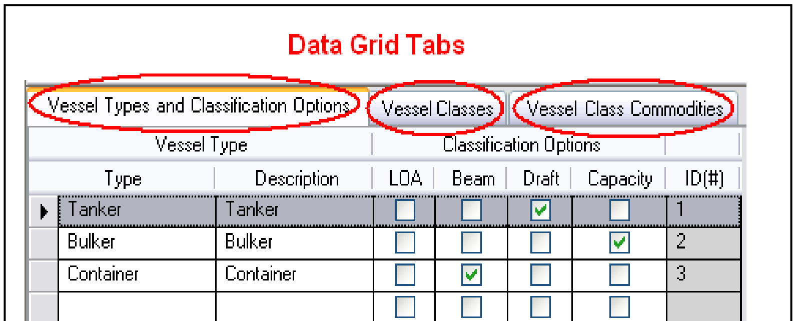

Figure 8: Data Grid

3.5 Model Outputs

There are three primary forms of HarborSym model output: (a) information stored back into the databases associated with a scenario, (b) detailed output files for the scenario, and (c) detailed

outputs generated in the Scenario Output Database (.SODA). The information stored back into the databases is used to display individual and comparative results for scenarios through output reports. The output files are used for verification of input, and detailed exploration and debugging of model behavior. Model outputs are discussed in greater detail in Section 9 and Appendix C. The Loading Modules have similar outputs, as described in Appendix E.

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Section 4

Loading Modules Overview

HarborSym does an analysis of a vessel call database (VCDB), developing detailed cost data for the situation presented in the data. Typically, the existing condition VCDB will be based on historical vessel call data, but projections must be developed for future and with-project situations. Separate HarborSym simulations are made for the without- and with-project conditions, for existing conditions and projected futures for the desired planning horizon.

A complication in using HarborSym for planning studies is thus the generation of vessel call lists that represent fleet arrivals and loadings under future without- and with-project conditions. That is, a with-project vessel call list must represent the future fleet and commodity demands for import and export at the port and the associated commodity transfers and vessel loadings must be reflective of the possibilities offered by the channel improvements.

A number of tools, referred to as the HarborSym Loading Modules, were added to HarborSym to assist the user in developing data required for a widening and/or deepening project. Specifically, these modules assist the user in developing a synthetic VCDB that satisfies a given commodity forecast for non-containerized and containerized ships respecting the depth constraints of the docks and the available fleet.

Given the distinct nature of non-containerized and containerized ships, separate tools were developed to address their specific vessel loading behavior. The Bulk Loading Tool (BLT) module generates a synthetic future VCDB based on user provided information on the fleet and commodity demands for all non-containership vessels, such as break-bulk, bulk carriers, barges, cruise ships, and tanker vessels. The Container Loading Tool (CLT) module produces a containership-only synthetic VCDB based on user inputs describing commodity forecasts at docks and the available fleet. Given the nature of the HarborSym database structure, the BLT and CLT-generated VCDBs must be combined into a single VCDB for cases where both types of traffic are to be modeled in HarborSym. The Combiner module was developed to address this need.

The loading Modules are launched from the HarborSym Tools menu. The following sections provide an overview of the Loading Modules, including the architecture, basic concepts, input requirements, processing behavior, and user interface. Details on how to use the Loading Modules to generate a synthetic VCDB for use in a HarborSym simulation are provided in Section 7.

4.1 Bulk Loading Tool

HarborSym includes the BLT module that can be used to generate synthetic vessel call lists for general bulk carriers. Due to the nature of the data required by the BLT and the BLTs use of data already entered for a HarborSym study, completing historical information on vessel calls into HarborSym is the appropriate starting point for an analysis. Synthetically generated vessel call lists facilitate forecast changes in commodity transfers and fleet variations over the project life. The general features and capabilities of the BLT include:

- Population of all vessel call data fields necessary to run HarborSym;

- User supplied annual commodity forecasts at the dock level;
- User supplied forecasts of annual fleet availability at the vessel class level, in terms of the number of vessel calls in a year made by the class;
- Development of synthetically generated vessels with explicit physical characteristics based on statistical models;
- Loading the available fleet in order to satisfy dock level import and export forecasts;
- Focus on bulk, general cargo, and other vessel types that operate on a "there and back again" service route, due to the unique behavior and data requirements necessary for forecasting and loading containerships.

The BLT is designed to process two unique steps to generate a shipment list for use in a HarborSym analyses. First, a synthetic fleet of vessels is generated that can service the port. This fleet includes the maximum possible vessel calls based on the user provided availability information. Second, the commodity forecast demand is allocated to individual vessels from the generated fleet, creating a vessel call and "using up" an available call from the synthetic fleet. Additional details on each of these steps are provided in subsequent subsections.

4.1.1 Architecture

A single HarborSym study is composed of several distinct Microsoft® *Access* databases, as outlined in Table 1. The BLT has been designed to reduce the amount of data input required by the user. Rather than reassert the basic parameters of the study, such as docks, vessel types, commodities, and route groups, the user can direct the BLT to the HarborSym IDB that already contains this information. Additionally, the BLT can be directed to a historical VCDB that contains pertinent vessel class information that is used to create the synthetic vessels for the future call list. This feature of the module not only saves the user time by eliminating the need for duplicate data entry, but it also ensures the accuracy of the data and its consistency with a HarborSym IDB. Figure 9 provides the schematic overview of the database relationships within the BLT architecture.

The user must link the BLT module to the appropriate input (IDB), vessel call (VCDB), and forecast (FCDB) databases. The IDB, or input database, describes the project layout, including the docks, vessel types, vessel classes, and commodity categories. Note that any changes in vessel characteristics, commodities exchanged, or vessel route groups from the historical condition must be implemented within the IDB through the HarborSym UI. For example, a new class or type of vessel calling the port must be added to the project through HarborSym, including data regarding vessel docking and undocking times, vessel turning times, vessel Route Group assignments, changes in design parameters, etc. The same premise is true for changes in docks (including new docks or more depth at existing docks), commodities transferred at the port, and Route Groups changes anticipated for the future. All data fields in the IDB must be complete.

The VCDB, or vessel call database, documents the unique vessels that call the port, and all the calls and commodity transfers made by these vessels. Initially, a populated VCDB, possibly housing the existing condition call list, should be attached to the BLT. An existing condition (or other populated vessel call database) is used to populate basic information for the BLT forecast, such as the logical constraints and vessel class statistics.

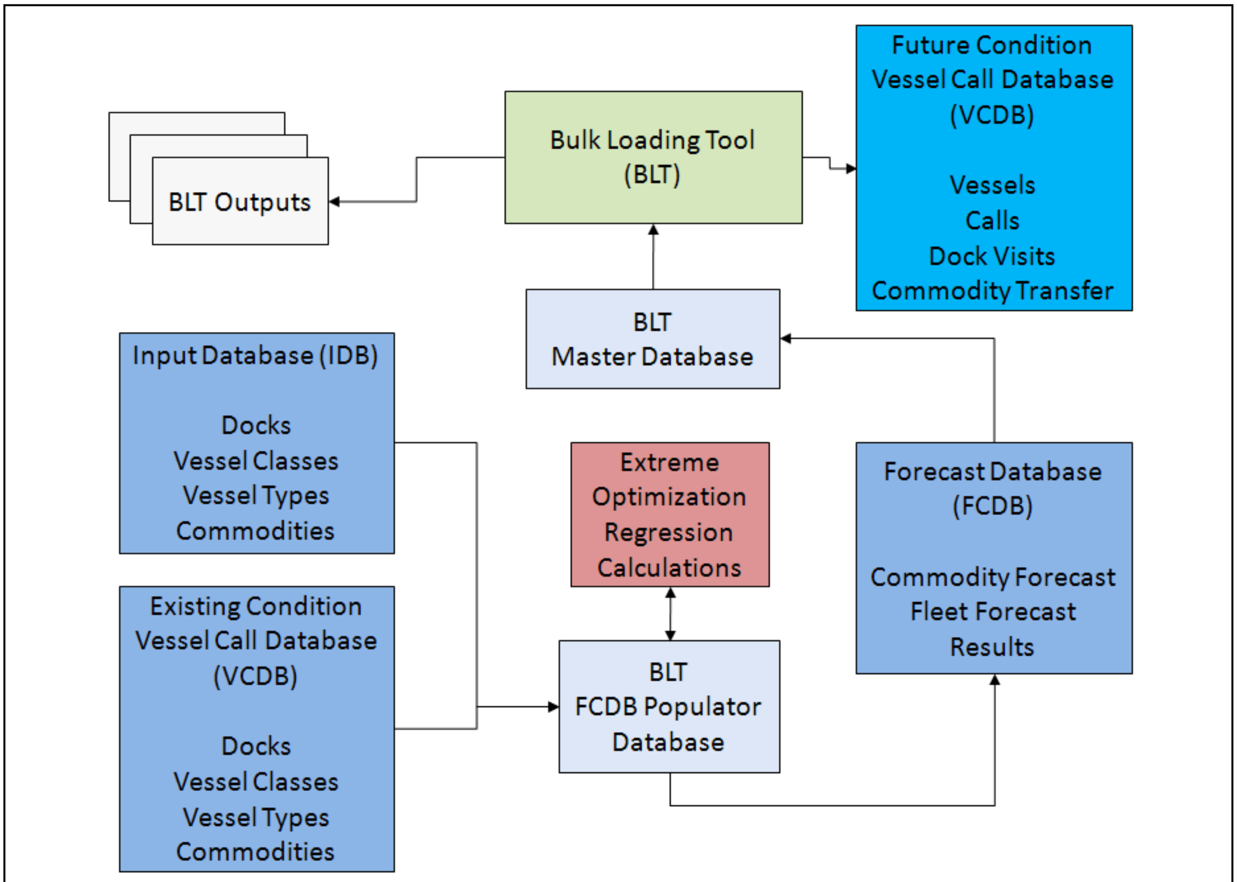

Figure 9: Bulk Loading Tool Architecture

The final database that must be attached is the FCDB, or forecast database. This database is unique to the BLT and stores information about commodity forecasts at docks, constraints on vessel class capability to carry commodities and serve individual docks, and the vessel fleet. In addition, the statistical information necessary to generate synthetic vessels is stored in this database.

4.1.2 Input Requirements

Users must provide data to specify the framework for generating the synthetic vessel call list. In addition, the user must specify all vessel characteristic categories within the HarborSym UI because these are used as data checks, see Section 6.3. Within the BLT, the input requirements include:

- Commodity forecasts (annual import/export) at each dock;
- Description of the available fleet by vessel class, including:
    - Statistical data describing the cumulative distribution function for deadweight tons of vessels within the class,
    - Regression information for deriving length overall (LOA), beam and design draft from capacity,
    - Regression information for calculating TPI based on beam, design draft, capacity and LOA;

- The number of potential calls that can be made annually by each vessel class;

- Logical constraints describing:

  - Commodities that can be carried by each vessel class,

  - Vessel classes that can be serviced at each dock,

  - Parameters, defined at the vessel class/commodity level for determination of how individual calls and commodity transfers are generated, such as commodity loading factors, allocation priorities, and commodity flow direction (import or export calls).

The above listed user provided information describing forecast conditions is entered through the BLT UI and is stored in an *Access* database referred to as a forecast database, with an .FCDB extension. General project-wide information, such as vessel class definitions and dock descriptions, is stored in separate databases. Under a typical work flow, the project-wide information will be populated in the HarborSym Navigation Pane (see Section 6), and the user will direct the BLT to these populated databases prior to generating a synthetic call list.

Procedures exist, using the Extreme Optimization package and some Access routines, to populate much of the required forecast information based on an examination of an existing vessel call list created from historical data. Statistical measures, commodity transfer amounts, and logical constraints can all be derived from an examination of a set of historical calls that have been stored in a HarborSym database. This populator function facilitates data entry by providing a basis for the forecasts, which the user can edit as necessary. Section 7.1 describes the steps to create a synthetic call list using the BLT.

4.1.3 Model Behavior

With the user provided input requirements identified in the previous section, the BLT creates and loads a synthetic fleet according to the following steps.

1. Generation of a fleet of specific vessels based upon a known number of vessel calls by class and a statistical description of the characteristics of the vessel class. This process begins by generating one specific vessel for each call in the class. The capacity of the vessel is set by a random draw from the cumulative density function that is stored for the class. Based on the regression coefficients that are stored for the class, each of which is of the form:

   $$\log(\text{parameter}) = a + b^* \log(\text{Capacity})$$

   LOA, Beam and Design Draft are determined for the vessel using a linear regression of the form:

   $$\text{TPI} = a + b^*\text{Beam} + c^*\text{Design Draft} + d^*\text{Capacity} + e^*\text{LOA}$$

   The TPI is calculated based on the previously generated physical characteristics and coefficients stored, at the class level, for this regression model. This process is repeated until a unique vessel is created for each available call in the forecast. If no TPI is generated, the default TPI from the linked IDB for the vessel class is assigned.

2. Attempt to assign a portion of the commodity forecast at a dock to a vessel. Each commodity forecast at a dock is processed in turn. If a vessel is available that can serve the commodity at the dock, it is loaded for either export only, import only or both export and import. Potential vessels that can carry the forecast are assigned in a user-specified (at the class level) allocation order, so that the most economical vessel classes will always be used first. Under the current assumptions, a vessel call handles a single commodity at a single dock, i.e., each call consists of a single dock visit and a single commodity transfer (which may contain both an export quantity and an import quantity). The specification of the actual call assignment and commodity loading is dependent upon the maximum that a vessel can draft and still reach and leave the dock.

   The amount of the commodity forecast that is actually carried on the vessel is used to decrement the remaining quantity to be allocated for that particular commodity forecast. After a single vessel call is assigned to a particular forecast, the total number of remaining available vessels for the class is decremented and the next commodity forecast in turn is processed. That is, each forecast attempts to have a portion of its demand satisfied by a single vessel call and then the next forecast is processed. This is to prevent all of the most efficient vessels from being assigned to a single commodity forecast.

   This process proceeds, in a loop, continually attempting to assign commodity to a vessel from the remaining available fleet. Whenever a successful assignment is made, this generates a vessel call, dock visit and the associated commodity transfer. This effort continues until no more assignments to a vessel call can be made, either because all commodity forecasts have been satisfied or there is no available vessel that can service the remaining quantities (because there is no vessel of the required class that can handle the particular commodity/dock combination of the forecast or because no vessel can be loaded to satisfy the dock controlling depth constraint).

3. At the end of the process, when no more assignments are possible, arrival times are assigned for each vessel. The algorithm used to assign arrival times assumes a uniform inter-arrival time for all calls within a class. After the allocation process is complete, the number of calls made by each class of vessel is known. This is used to calculate the inter-arrival time of vessels for that class. The arrival of the first vessel in the class is set randomly at a time between the start of the year and the calculated inter-arrival time, but all subsequent vessel arrivals for the class will have the identical inter-arrival time.

4. The generated vessel calls are written to a HarborSym vessel call database and the user is presented with output information on which commodity forecasts were satisfied, any remaining unsatisfied forecasts and detailed information on each vessel loading and the vessels that were used to satisfy each commodity forecast.

The intended approach is for the user to work iteratively within the BLT, making runs, examining the forecast satisfaction that is achieved and varying the fleet character and composition for subsequent runs, so that the final result is a balanced, reasonable projection of vessel calls to satisfy the input forecast demand. The BLT provides extensive output to assist the user in this regard.

Once a vessel is determined to be available for loading for a particular forecast, the BLT must determine the type of loading, the quantity loaded and the arrival draft of the vessel. The user can control certain aspects of the process through data specification, in particular the type of call (import, export or both) and the percent of capacity that is loaded for import and export, as described below.

Any given vessel call can attempt to satisfy an import demand (arrive with cargo for the port, leave empty), an export demand (arrive empty, leave with cargo loaded at the port) or simultaneously an import and export demand (that is, arriving with cargo to unload at the port [import], and then departing with cargo bound for another port [export]), based on the user defined directional movement assigned to the vessel class. Four possibilities are defined for this behavior, with specification at the Vessel Class/Commodity Category level:

- Export Only
- Import Only
- Random
- Both Export and Import

Certain combinations of class and commodity categories might be exclusively import only or export only. A “Random” assignment designates that calls from the class/commodity combination can be either import or export at a dock, but not both simultaneously. If a “Random” type is assigned, then the ratio of calls that will be randomly generated as import is specified.

The quantity of a vessel’s capacity that is to be loaded for satisfaction of the import and export demands is described, again at the Vessel Class/Commodity Category level, by a triangular distribution that specifies a loading factor. A minimum, most likely, and maximum, in percent of total available capacity, is defined for both export and import.

When a vessel is available for satisfying a demand, first the type of satisfaction (import only, export only, random or both) is determined, as noted above. If “random” is associated with the current class/commodity, then a random draw is made from a uniform distribution and compared with the user-specified import ratio, to determine if the call is import only or export only. For example, if the user has entered a value of 70 percent for imports, indicating that 30 percent of the calls are exports, then a random draw is made from a uniform (0,1) distribution. If the random number is less than or equal to 0.7, then the call is assigned as an import, otherwise it is assigned as export.

Once the type of call is determined, the BLT must next ascertain how much capacity can be loaded on the vessel while satisfying the draft constraints. The process is similar for both export and import. First, a draw is made from the respective triangular distribution to get a percentage loading factor. This is then applied to the vessel DWT, adjusted to reduce the available tonnage based on allowance for operations, to get a tentative quantity to be loaded. The import/export capacity to be loaded is adjusted only if the available loading capacity is less than the initial calculation (see Appendix E.2.3 for specifications on tentative loading).

The tonnage associated with allowance for operations is based on IWR-developed data given fractional allowance for operations as a function of vessel tonnage (DWT), see Figure 10. The additional draft implied by the tentative quantity to be loaded is calculated based on the vessel TPI. A value of empty vessel draft for each vessel has previously been calculated, based on an assumption that the vessel DWT is associated with the vessel design draft. The empty vessel draft from which loading can start is then calculated as:

$$\text{Empty Vessel Draft} = \text{Design Draft} - (\text{DWT}/\text{TPI})/12.0$$

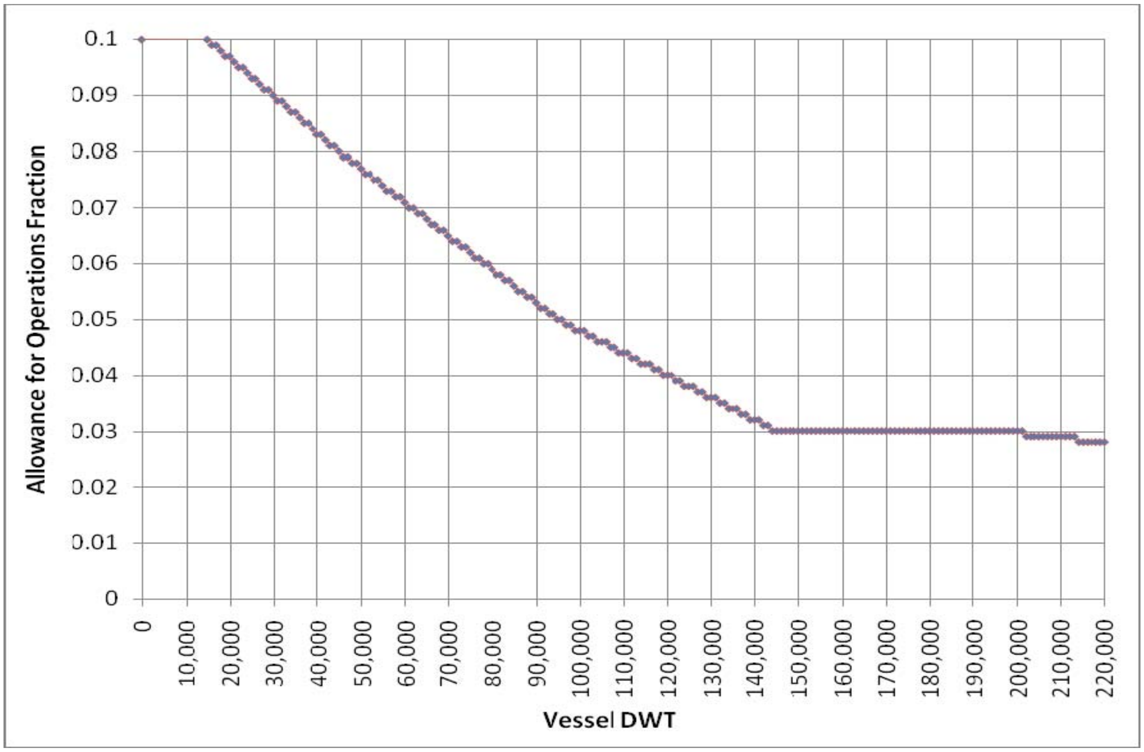

Figure 10: Allowance for Operations by Vessel DWT

The total draft associated with the tentative loading is then calculated as the sum of four drafts:

Total Draft (tentative loading) = Empty Vessel Draft + Additional Draft Associated with Tentative Loading + Additional Draft associated with Allowance for Operations + Underkeel Clearance

In order to test the ability of the vessel to arrive at or leave the dock, to this total draft associated with tentative loading must be added the required underkeel clearance (a function of the vessel class). This gives the "test draft" that is checked against the limiting depth to the dock. Note that this is not the same as the eventually calculated arrival draft of the vessel at the bar, which is written to the vessel call data base. If this test draft is greater than the limiting depth to the dock (as defined by user input), the quantity loaded must be reduced, so that the calculated draft is less than the limiting depth to the dock. This calculation is executed to determine if the tentative loading can be reduced sufficiently to meet the dock limiting depth. If so, then the vessel is loaded with the amount of commodity to reach the target draft. If it is not possible to assign a commodity quantity that, when loaded on the vessel, does not exceed the dock limiting depth, then the vessel cannot service the allocation.

Once the commodity allocation has been completed, the vessel loading is known and the arrival draft (at the bar) must be determined. A class level "minimum sailing draft" has been specified by the user at the vessel class level. This minimum sailing draft, or empty vessel draft, reflects the ballasted draft at which a light vessel will sail. If a vessel is handling an export only, then it is assumed to arrive light, at the empty vessel sailing draft. If a vessel is handling an import to the port, then it arrives at the draft associated with the import loading (which may have been reduced to the limiting depth at the dock). It is important to note that underkeel clearance is not included in the arrival draft that is stored in the

vessel call database because it does not factor into the actual sailing draft, but, as noted above it is used in checking the constraint associated with the limiting depth to the dock. In practice, underkeel clearance is used in the BLT to handle the depth constraint, but is not incorporated in the actual sailing draft. Underkeel clearance is then added back in as an additional constraint that is applied in HarborSym itself based on sailing rules. In this manner, the arrival draft is consistently calculated based on the sum of empty vessel draft, draft associated with loading, and draft associated with allowance for operations.

The BLT module writes all the needed fields to the vessel call database. Of note is how the ETTC field is handled. Within the BLT, ETTC is populated by simply adding together import tons and export tons. As discussed in Section 3. 3.1, the ETTC field is used by the HarborSym kernel to allocate at-sea costs to the subject port. Because the BLT is populating the field as such, the assumption is that all at-sea costs for a vessel call generated by the BLT are allocated to the subject port. If the user has information that partial loading and unloading is occurring, the ETTC field should be manually adjusted accordingly.

Also, note that allowance for tide is not explicitly incorporated in the BLT. Users can factor in tide height availability by adjusting the dock limiting depth accordingly.

4.1.4 BLT User Interface

The BLT UI is composed of four menu options and three distinct panes, the Navigation Pane, Data Pane, and the Options Pane, as shown in Figure 11. Under 'File', selecting the 'Close' option will exit the BLT application. Selecting the 'Options' menu will provide a list of several databases needed for the BLT to properly function. These files are included with the HarborSym installation. These files locations are automatically specified during the HarborSym installation process. Specification of these files will not be required by the average user. The 'Diagnostics' menu allows the user to Optimize

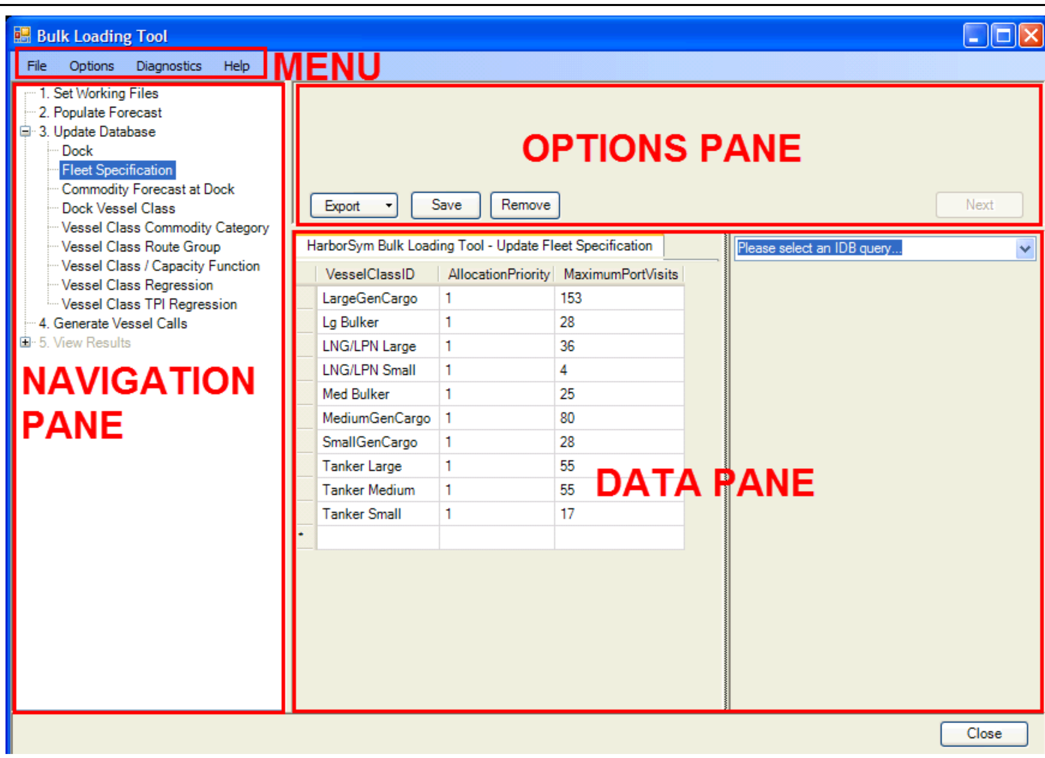

Figure 11: Bulk Loading Tool User Interface

Master MDBs, which will launch a procedure to improve the speed of the BLT database processes. Finally, the Help menu provides an 'About' option that, when selected, will display the version number of the BLT.

The Navigation Pane provides the user with a tree structure that has 5 numbered items, Number 3 and Number 5 have sub-items available. The items found in the Navigation Pane are numbered according to the order the user should follow to create a synthetic vessel call list for generalized bulk traffic. According to which item is selected in the Navigation Pane, different options will be available in the Options Pane, and different data will display in the Data Pane. Details on how to use the Navigation Pane to review and edit data are provided in Section 7.1.3.

4.2 Container Loading Tool

The CLT module produces a containership-only synthetic future vessel call list based on user inputs describing commodity forecasts at docks and the available fleet. The module is designed to process in two unique steps to generate a shipment list for use in HarborSym or in standalone analyses. First, a synthetic fleet of vessels is generated that can service the port. This fleet includes the maximum possible vessel calls based on the user provided availability information. Second, the commodity forecast demand is allocated to individual vessels from the generated fleet, creating a vessel call and fulfilling an available call from the synthetic fleet.

In order to successfully utilize this tool on a planning study, users will need extensive data describing containership loading patterns and services frequenting the study port. The user must provide a vessel fleet forecast by vessel class, season, and service, and a commodity forecast by dock, season, and region. A solid understanding of anticipated shipping patterns, loading behaviors, and forecast demands will be necessary to generate future call lists using the CLT. Section 7.2 provides details on how to use the CLT to generate a future synthetic call list.

4.2.1 Architecture

A single HarborSym study is composed of several distinct Microsoft® *Access* databases. Before generating synthetic call lists, users must first attach the CLT module to the appropriate master, input, vessel call, forecast, and geography databases. Table 1 describes the different information contained in each database. Figure 12 provides a schematic overview of the CLT database architecture.

The Master database links together all relevant information needed for CLT generations. This database location should be specified first prior to specifying the additional databases. It can be found in the HarborSym programs files location, most typically at C:\Program Files\HarborSym. The file is named 'CLTGeneratorMaster.mdb'. If the user resets the link to the Master database, links to the remaining databases will be broken and will need to be reestablished.

The IDB, or input database, describes project layout, including the docks, vessel types, vessel classes, commodity categories, and route groups. It is important to attach the CLT module to the correct input database as this database defines the vessel and commodity classifications that provide the basis for a synthetically generated call list. Typically, the IDB specified here will be the HarborSym IDB corresponding to the future project for which the CLT is being used to generate a synthetic VCDB.

The VCDB, or vessel call database, documents the unique vessels that call the port, and all the calls and commodity transfers made by these vessels. The CLT vessel call database generation process varies

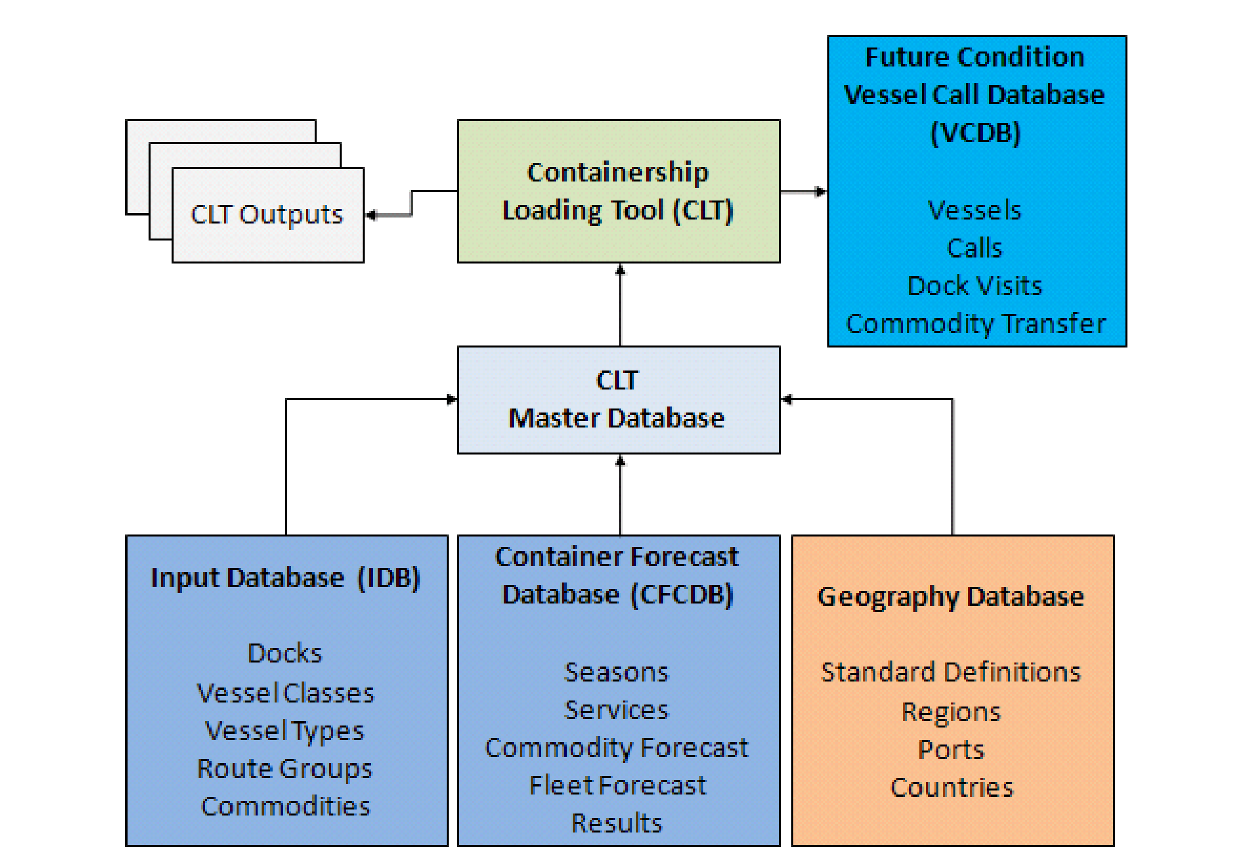

Figure 12: CLT Architecture

from the BLT process in that the user will direct the CLT to create a VCDB from template rather than starting with an existing condition VCDB.

The next database that must be specified is the CFCDB, or containership forecast database. This database stores information about commodity forecasts at docks, the container fleet specification, parameter settings, seasons, dock parameters and vessel class specifications, services, regions, route groups, arrival draft functions, and vessel subclasses. Initially, a blank CFCDB should be attached to the CLT.

4.2.2 Input Requirements

Developing a containership vessel call forecast requires extensive data collection, processing, and input. The following describes the data requirements of the CLT in detail.

Seasons

Seasons are defined by the user and must cover the entire year. Each season is specified by a start month and day and an end month and day. The user can define as many seasons as necessary and apparent at the port of study.

Regions

Regions are defined in the Geography database and are not editable by the user. It is, however, important that the user knows the regions available so that a commodity forecast by region can be

developed. The defined regions with detailed information can be found through the View Tables/Geography/Region menu option.

Commodities

Commodity category information is stored in the HarborSym IDB linked to the CLT. It is visible from within the CLT UI in the standard data grid format but the user is prevented from editing this data to avoid creating conflicts with usage in HarborSym simulations.

Commodity Forecast at Dock

Forecasts are defined at the commodity, dock, season, and region level as import and export quantities in metric tons. This information is stored in the CFCDB, and is user-editable. A forecast name is also provided (e.g. “FC1”) for use in referencing output to a particular forecast.

Service

In the context of the CLT, a service is a regular vessel transit across a set of regions. Services are not necessarily defined at the port level but rather represent a larger-picture for the vessel. Within the geographic hierarchy defined in the Geography database, a port lies within a country and a country falls within a region. Services are user-defined within the CLT and stored in the CFCDB. The user defines the Service name and description. The IWR developed A-DAPP tool provides detailed information on service for a given port and vessel call. Through use of the A-DAPP and the IWR created W-DAPP, the user has the tools and data necessary to populate Service data for the CLT. See the A-DAPP and W-DAPP User’s Guides for details on how to process the service information.

Additional data relating to Services must be populated in the CLT:

- Correspondence between Services and Regions (region-service);
- Association of Route Groups (defined in HarborSym and viewable through the CLT IDB link) to Services (route group-service) including the percentage of Route Groups traversing a given Service;
- Detailed information on containership characteristics sailing on a particular Service (service-vessel class) such as arrival draft CDFs, average lading weight per loaded TEU, average container weight per TEU, empty TEU allotment, vacant slot allotment, allowance for operations, variable ballast, minimum and maximum arrival draft (if arrival draft CDF is not available), and import and export fraction triangular distributions.

Fleet Specification

A fleet specification is defined as a maximum number of port visits within a given season of a vessel of a given class, operating on a particular service. A specification essentially says: “In the first 6 months of the year, there are 30 available calls of Subpanamax vessels operating on the East Coast US – South America Pendulum service”. An allocation priority is assigned to individual fleet specifications, and the CLT observes these priorities, attempting to fill a forecast by using vessels from the fleet with the highest allocation priority before using vessels of a lower priority. Note that the highest allocation priority is 1, the larger the number, the lower the priority.

Route Groups

The Route Group is as specified through the HarborSym UI and is stored in the IDB. It is a statistical abstraction of a portion of a service, centered on the subject port, with information on distribution of

distances to prior and next ports and at sea distance, allowing for a total voyage length determination, and fixed values for prior and next port limiting depths, used in the allocation process. Inasmuch as a service is a larger-area, region to region movement, and does not take into account movement between ports within a region, the hierarchy is service – route group, such that total traffic on a service can be assigned, based on user percentages, to individual route groups within that service. Route Groups are defined in the HarborSym user's interface. For details see Section 3.2.8, Vessel Route Groups.

Constraint Tables

A number of data tables provide logical constraint information, defining what vessel classes can use a specific dock, the association of regions to services, etc. The constraints are based upon concepts employed in the BLT framework. These are user-editable tables, located in the CFCDB.

- Dock - Vessel Class

  - This table identifies the vessel classes that can use a particular dock, and thus are available to satisfy forecasts at that dock.

- Region – Service

  - The region-service table identifies the regions that are visited by a particular service. The order is not important. This table allows the CLT to identify all of the services that can be used to satisfy a particular forecast to a given region. The Services table must be completed prior to populating this table.

- CLT Parameters

  - This table is designed to store, in a tag-value format, information for the simulation. The tag-value format is easily extended as new port-wide values are incorporated in the CLT algorithms. This is similar to the "configurations settings" table in the main HarborSym module, which is modified with additional user-defined simulation parameters as needed. At present, the only value in this table is for a port-wide sea level change value.

- Dock Parameters

  - The dock parameters table currently stores additional tidal availability at the dock, in feet. This information is used, with other information, to determine feasible loading depth of a vessel for the given dock. Note that there is no duration associated with this value, it is assumed that the additional tidal value can be used by the vessel in reaching the dock. The IWR-created TideTool can be used to determine the additional tidal availability at a given dock.

- Route Group – Service Assignment

  - The geography hierarchy has route groups as a subset of services. That is, a service, which is defined at the region to region level, can have many route groups, which are defined at the abstract port to abstract port level. The route group – service assignment table associates route groups with services, and defines a numerical value indicating how many calls assigned to the service should be assigned to the specific route group. Note that the percentage assignment of Route Groups should add up to 100 for each Service. The A-DAPP

provides details on the service and route group for a given call. This information can be used in conjunction with the W-DAPP to determine the statistics necessary to populate this table.

- Service-Vessel Class

  - Three basic types of information are stored within the table: 1) information for use in determination of arrival draft; 2) information for use in the loading analysis; and 3) information for use in determining the fraction of the vessel load on arrival that is imported/exported to the subject port. All of this information is stored in a single table within the CFCDB, but is shown in three parts for clarity. The user can provide either:

    - A minimum/maximum arrival draft for a vessel class on a given service, in which case the generation process selects randomly between the two values to assign arrival draft to a vessel; also necessary to bracket the CDF functions, or

    - A cumulative distribution function (CDF) of arrival drafts, in which case the generation process uses the CDF to randomly assign the arrival draft.

    - If no CDF values are known then a “NULL” [must be exact] CDF function must be specified and then the CLT generator will automatically use the min/max arrival drafts. Note, however, that if CDF values are provided, then the min/max arrival draft fields must be specified. The CLT vessel generation process will check that the randomly drawn CDF value is within the min/max.

  - CDF information is available from the A-DAPP, and is stored in editable function tables. Note that CDF functions will need to be expanded by the user in the with-project condition to account for vessels arriving at the port of study drafting deeper as the with-project channel depth allows.

The following information is used in conjunction with the arrival draft determined using the information above to determine the allowable tonnage that can be carried on arrival: vessel-specific information on design draft and TEU rating, limiting depths, and tidal availability.

It is assumed that the import/export quantities to the subject port are based on historical fractions of vessel loading. This information is characterized as triangular distributions for each of import and export, with P1 being the minimum, P2 the most likely and P3 the maximum percentage of total loading that is imported/exported.

Vessel SubClasses

Within the CLT process, a vessel call is created based on a vessel class. Specific vessel characteristics are determined by choosing a vessel from the vessel subclass table. The subclass table provides standard vessel data for sets of vessels within a given vessel class. This information has been defined by IWR for container ships, with 45 distinct subclasses for four vessel classes (SubPanamax, Panamax, PostPanamax Gen1, and PostPanamax Gen2), and should not be changed by the user. The proportional assignment of vessel subclasses to a class is a user-entered parameter, defined in a similar fashion to the percentage assignment of route groups to services. The only thing that should be changed by the user is the percentage of subclass assignment to the vessel class. The total percentage within a class should sum to 100. Any subclasses not servicing the port can be removed (deleted) from the data grid.

4.2.3 Model Behavior

The CLT generates a vessel call list by first generating a synthetic vessel fleet based on user inputs. Each vessel in the fleet is randomly assigned physical characteristics based data within the Vessel-Subclass table.

Tentative arrival draft is determined for each generated vessel based on the values contained in the Service Vessel Class table. This table contains a minimum arrival draft, a maximum arrival draft, and optionally, the name of a stored CDF of arrival drafts. If a stored CDF is available, then a random draw is made from that CDF. The randomly drawn value is tested against the limits of minimum and maximum arrival draft, and if the CDF value is outside of that range, it is set to the appropriate limit (minimum or maximum arrival draft).

If no CDF is available (Function Description = "NULL"), then a random draw is made from a uniform distribution between the minimum and maximum arrival draft.

The arrival draft is initially set to the tentative arrival draft, as determined above.

The Maximum Allowable Arrival Draft is determined as the minimum of:

1) prior port limiting depth
2) design draft
3) limiting depth at the dock + underkeel clearance + sinkage adjustment + tidal availability + sea level change

The arrival draft as calculated above (i.e. tentative arrival draft) is then compared to the Maximum Allowable Arrival Draft, and set to the lesser value, that is, either the statistically estimated value or the constrained value.

Next, the CLT conducts a Loading Factor Analysis (LFA) given the physical characteristics of each generated vessel. LFA explores the relationships between a ships physical attributes, considerations for operations and attributes of the trade route cargo to evaluate the operating efficiencies of vessel classes at alternative sailing drafts. Several intermediate calculations are required. The following variables are used by the load factor analysis model but are calculated from the inputs.

- Vessel operating cost per 1000 miles is calculated as 1000 miles divided by the applied speed times the hourly at seas cost.
  <u>= 1000 miles / (Applied Speed X Hourly Cost)</u>

- The allocation of vessel space to vacant slots, empty and loaded containers is calculated by adding the cargo weight per box plus the box weight plus an allowance for the empty.

- Total weight per loaded container =
  Average Lading Weight per Loaded TEU by Route (Metric Tonnes)
  + Average Container (Box only) Weight per TEU (Metric Tonnes)
  + (Average Container (Box only) Weight per TEU (Metric Tonnes)*(Percent Empty TEUs))

- Shares of vessel capacity are then calculated as:

- Cargo Share = Average Lading Weight per Loaded TEU by Route (Metric Tonnes)
  Total weight per loaded container in Metric Tonnes

- Laden Container Share = Average Container (Box only) Weight per TEU (Metric Tonnes)
  Total weight per loaded container in Metric Tonnes

- Empty Container Share = ((Average Container (Box only) Weight per TEU (Metric Tonnes))*(Percent Empty TEUs))
  Total weight per loaded container in Metric Tonnes)

▪ Volume capacity limits are calculated as follows:

  - Number of vacant slots = Nominal TEU Rating * Percent Vacant Slots
  - Max Occupied Slots = Nominal TEU Rating - Number of vacants slots
  - Max Laden TEUs = Occupied Slots/(1+Percent Empties)
  - Max Empty TEUs = Occupied Slots - Laden TEUs

▪ Maximum Volume Restricted Tonnage is then calculated as:

  - Max weight for cargo (tonnes) = Max Laden TEUs * Average Lading Weight per Loaded TEU by Route (Metric Tonnes)
  - Max weight for laden boxes(tonnes) = Max Laden TEUs * Average Container (Box only) Weight per TEU (Metric Tonnes)
  - Max weight for empties(tonnes) = Max Empty TEUs * Average Container (Box only) Weight per TEU (Metric Tonnes)
  - Total volume restricted tonnage (cubed out tonnage)(tonnes) = Max weight for cargo + Max weight for laden boxes + Max weight for empties

The load factor analysis proceeds as follows:

▪ The initial draft is varied from the vessels maximum (loaded) to minimum (empty). At each sailing draft the total tonnage that can be carried is calculated using the TPI rating for the vessel.

  - Deadweight Tonnage Available for Vessel Draft = Deadweight Tonnage Rating (Metric Tonnes) – [(Aggregate Maximum Summer Load Line Draft – Sailing Draft)*12 inches*TPI]

▪ This capacity is then allocated, first to ballast and operations to yield capacity available for cargo.

  - Approximate Variable Ballast = Deadweight Tonnage Available for Vessel Draft * Percent Assumption for Variable Ballast

    - Allowance for Operations in Metric Tonnes = Deadweight Tonnage Rating (Metric Tonnes) * Percent Allowance for Operations
    - Available for Cargo = (Deadweight Tonnage Available for Vessel Draft) - (Approximate Variable Ballast) - (Allowance for Operations)
- The capacity available for cargo is restricted if the vessel has “cubed” or “volumed” out:
    - Available for Cargo adjusted for volume restriction if any (tonnes) = the lesser of Available for Cargo and Total volume restricted tonnage (cubed out tonnage)
- The tonnage available for cargo is then allocated to cargo, laden and empty containers based on the shares of vessel capacity.
    - Distribution of Space Available for Cargo (tonnes) = Available for Cargo adjusted for volume restriction if any in Metric Tonnes * Cargo Share in percent
    - Distribution of Space Available for Laden TEUs (tones) = Available for Cargo adjusted for volume restriction if any in Metric Tonnes * Laden Container Share in percent
    - Distribution of Space Available for Empty TEUs (tonnes) = Available for Cargo adjusted for volume restriction if any * Empty Container Share
- The number of TEUs is then estimated for each share use:
    - Number of Laden TEUs = Distribution of Space Available for Cargo/Average Lading Weight per Loaded TEU by Route (Metric Tonnes)
    - Number Empty TEUs = Distribution of Space Available for Empty TEUs /Average Container (Box only) Weight per TEU (Metric Tonnes)
    - Occupied TEU Slots on Vessel = Number of Laden TEUs + Number Empty TEUs
    - Vacant Slots = Nominal TEU Rating - Occupied TEU Slots
- In the CLT the ETTC (estimate of total trip cargo) is calculated for each vessel call as the cargo on board the vessel at arrival plus the cargo on board the vessel at departure, in tons. See Section 3.3.1 for additional information on ETTC.

The CLT works to load each vessel available to carry the commodity on the given route until the forecast is satisfied or the available fleet is exhausted.

4.2.4 CLT User Interface

The CLT UI is essentially menu driven, as shown in Figure 13. The Title Bar provides the name of the module, version number, and release date. The Menu Bar has five options, as discussed below. The Quick Access Bar provides the user with options to quickly set the scenario form, generate a VCDB, and view results. These options can also be accessed through the menu. Standard Window Options are provided on the upper right hand of the module that allows the user to minimize, maximize, and close the CLT. Finally, the CLT has a Working Files pane that provides the link to the files that are attached to the CLT. The user can also specify new files using this pane by selecting the descriptive buttons to the left of each file link.

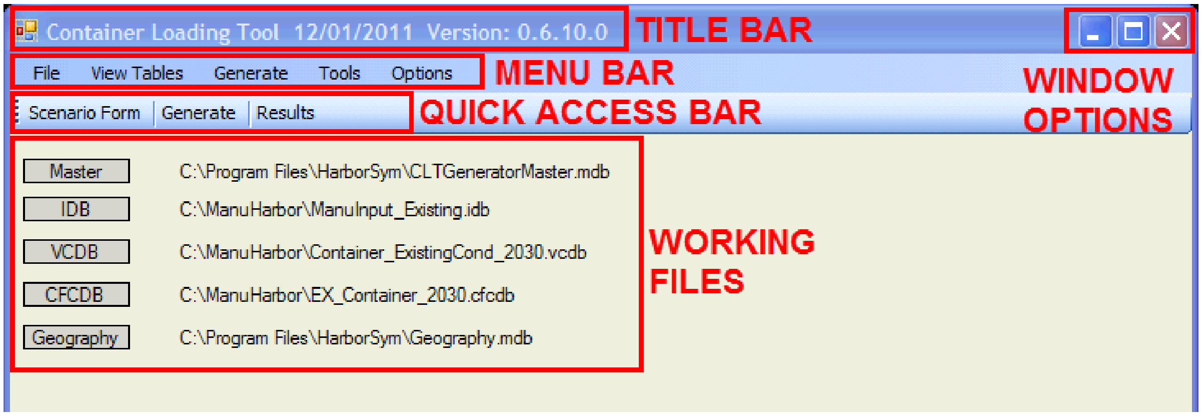

Figure 13: CLT User Interface Overview

The CLT has five menu options available to the user: File, View Tables, Generate, Tools, and Options. The CLT menu provides the user access to the data storage tables and processing tools needed to successfully create a VCDB for use in HarborSym. The following provides a general overview of the menu options available to the user:

- File: allows the user to specify the databases attached to the CLT (for reference databases are described in Table 1 on page 6), to save or load configuration settings, and to exit the CLT. See Section 2.3 for the location of the reference databases. File Menu options include:

  - Generator MDB: when selected, will allow the user to specify the location of the CLT Generator Master database. This database is named 'CLTGeneratorMaster.mdb'.

  - Geography MDB: when selected, will allow the user to specify the location of the Geography database required by the CLT. This database is name 'Geography.mdb'.

  - IDB: allows the user to specify the IDB database for which the current CLT study is based.

  - VCDB: allows the user to specify the VCDB that will be populated for a CLT study. Options are to Choose (an existing VCDB), Create From Template (will create a blank VCDB), or Copy Existing. Each unique HarborSym condition will require a new blank VCDB. Unlike the BLT, the CLT does not work from an existing VCDB created using HarborSym.

  - CFCDB: allows the user to specify the CFCDB that will be populated for a CLT study. Options are to Choose (an existing CFCDB), Create From Template (will create a blank CFCDB), or Copy Existing. Starting a new project will typically require the user to create a CFCDB from Template, while studies already in progress may utilize existing CFCDBs that were created with the CLT. This option will likely reduce the amount of data input required by the user as the data structure for a with- and without-project will be similar.

  - Load Config: will load the last saved file configuration.

  - Save Config: will save the current file configuration.

  - Exit: will exit the CLT. The user will be asked if the configuration settings should be saved. Select 'Yes' to save or 'Cancel' to exit without saving.

- View Tables: allows the user to view and/or edit the tables in the IDB, VCDB, CFCDB, and Geography databases. Selecting a table within any of the databases will open a grid view of the data. Fields that can be edited are colored blue and fields that are read only are colored white. Each table in the databases is described in detail the sections that follow.

- Generate: provides the user with menu options to check data, set scenario parameters, generate a VCDB, and view standardized result tables.

- Tools: includes options to expand three CFCDB tables based on information specified in associated tables.

  - Expand Service Vessel Class Table: once data have been specified in the Season, Service, and Container Fleet Specification tables found in the CFCDB, this option will create a data matrix in the Service Vessel Class table in the CFCDB.

  - Expand Dock Parameters Table: this option will expand the Dock Parameters table in the CFCDB according to the Docks specified in the IDB.

  - Expand Function Table: once the appropriate number of functions have been specified in the Arrival Draft Function table in the CFCDB, this option will expand the Arrival Draft Function Detail table in the CFCDB by adding 20 rows for X,Y data for each function specified.

- Options: allows the user to specify the CLT template directory and to specify options.

  - Set Template Directory: action that must be performed by user when CLT is first installed or if reinstalled on the user's computer. See Section 2.3 for the location of the Template Directory.

  - Set Options: allows the user to specify the output decimal precision for the output files available after VCDB generation. An option is also available to specify whether the graph is viewable during VCDB generation and if results are displayed once the generation process is complete. Finally, the user can specify for the CLT generator to write a debug file that provides details on the arrival draft.

4.3 Combiner Tool

The Combine VCDB module allows for the integration of the BLT vessel call list and the CLT vessel call list into one combined VCDB that can be used to simulate future traffic in HarborSym. The Combiner tool is quite simple to use. The user directs the Combiner to the VCDBs that are wished to be combined and to an IDB for which the data assumptions will be checked. The user may wish to implement the Data Check option, to ensure that the VCDBs correspond to the IDB. Section 7.3 provides details on how to use the Combiner Tool to generate a single VCDB using the combined output of the BLT and CLT modules.

4.3.1 Select Files

The VCDB Combine module takes as input four items. The user will need to attach an IDB against which the docks, vessel classes, and commodity categories are checked, two VCDB's, one created using the BLT and one from the CLT, and the desired combined VCDB. The user identifies the four files by clicking on each of the databases. These files can be saved under the file menu (Save Config). Load Config takes place automatically on program start-up.

4.3.2 Data Check

This check insures compatibility of the id's for vessel class, commodity category, and docks in each VCDB with the selected IDB. For proper behavior, both VCDB's that are to be combined need to reference a common set of categories, classes, and docks, so a reference IDB is provided to accomplish this test.

Since the VCDB carries only id's, not the definition of the id, all this check does is insure that there is no id number in the VCDB that is not also in the IDB. It does not insure that the meaning of the id is the same. For example, if the VCDB references vessel class id's 1, 4, 5, and the IDB has 1,2,3,4,5,6, then all is well. If, however, the VCDB references 1,4,5,7, a message will be generated. NOTE: the data check is optional, and is not tested before combining – the combine will still function even if the data check is failed.

The test also reports the number of unique vessels in each VCDB and the data range. The sum of the unique vessels should be less than the current HarborSym limit of 10,000, but the 10,000 value is not checked or enforced. If incompatibility is found, then a message dialog appears for the user.

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Section 5

Basic HarborSym Commands and Functions

A harbor is a structure of connected reaches, docks and facilities that must be established correctly to simulate traffic. Entering this information can be time consuming and has been a large consideration in the application development, leading to the implementation of many timesaving techniques. HarborSym uses a traditional menu as well as toolbars for immediate access to functions. When the user right-clicks on the map area of the graphics pane, a context-derived menu is displayed for the corresponding object. Message prompts are also applied for context menus.

The following chapter describes the basic menu commands and functions available in HarborSym. The menu commands are presented in the order that they appear on the menu toolbar of the main application window with explanations of what happens when the particular option is selected. Additional detail on the various HarborSym features and the approach to data population is discussed in Section 6.

5.1 File

The following items are found on the File menu pillar, as shown in Figure 14: "Study Manager, "Configuration Settings", and "Print."

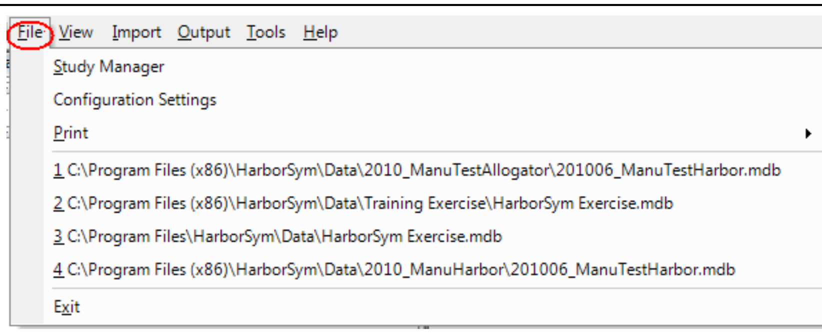

Figure 14: HarborSym File Menu

5.1.1 Study Manager

When the "Study Manager" item is selected, a dialog box is prompted. This dialog box allows the user to a create new project or open existing projects. Through this view the user can specify the file location for all projects within a study. The user will benefit by keeping all the files for a study in the same directory.

Study Manager allows the user to "clone" a project and thereby avoid duplicate data entry. The "cloned" project can then be modified to reflect the harbor improvement alternative being evaluated.

The details of this dialog box are discussed in Section 6.1, Studies and Projects, which also includes an explanation of the study/project hierarchy.

5.1.2 Configuration Settings

This function brings up the Configuration Settings form where validation and simulation settings can be input and edited. The validation settings, shown in Figure 15, are ranges of values, as set by the user, that are available for the user to define. HarborSym has a data validation tool that enables the user to verify that current HarborSym data values fall within these acceptable limits. Input values outside of the defined range generate warning and error messages during the data validation routine. Additional information on the data validation tool and ranges for validation settings is available in Section 6.11.

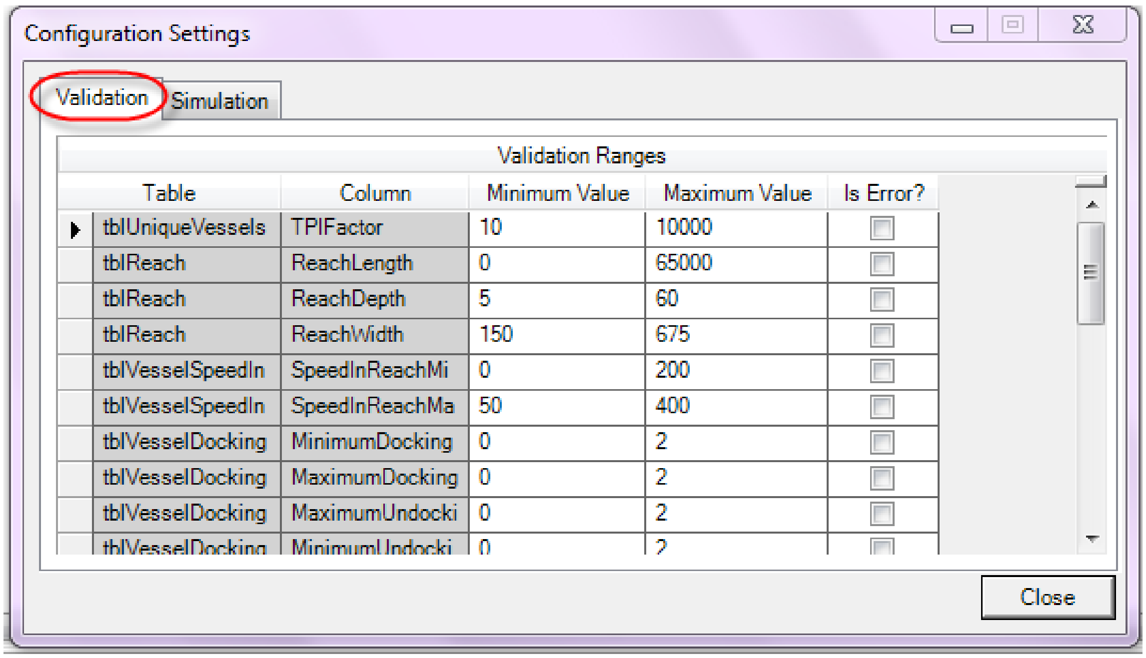

Figure 15: Configuration Settings - Validation

The second tab on the Configuration Settings window, shown in Figure 16, displays user-defined fields relevant to the simulation processing. These fields relate to vessel operating cost thresholds or priority vessel simulation duration (as described in Section 3.2.5), and other variable fields. The vessel leg wait limit count, for example, will impact the deletion of vessel calls if vessels become “stuck,” and cannot move because of vessel traffic rules. Complete descriptions of these settings can be prompted by hovering the cursor over the description block. Section 8.1, Table 7: Simulation Settings Fields, provides a description and explanation of all the simulation settings available in this tab.

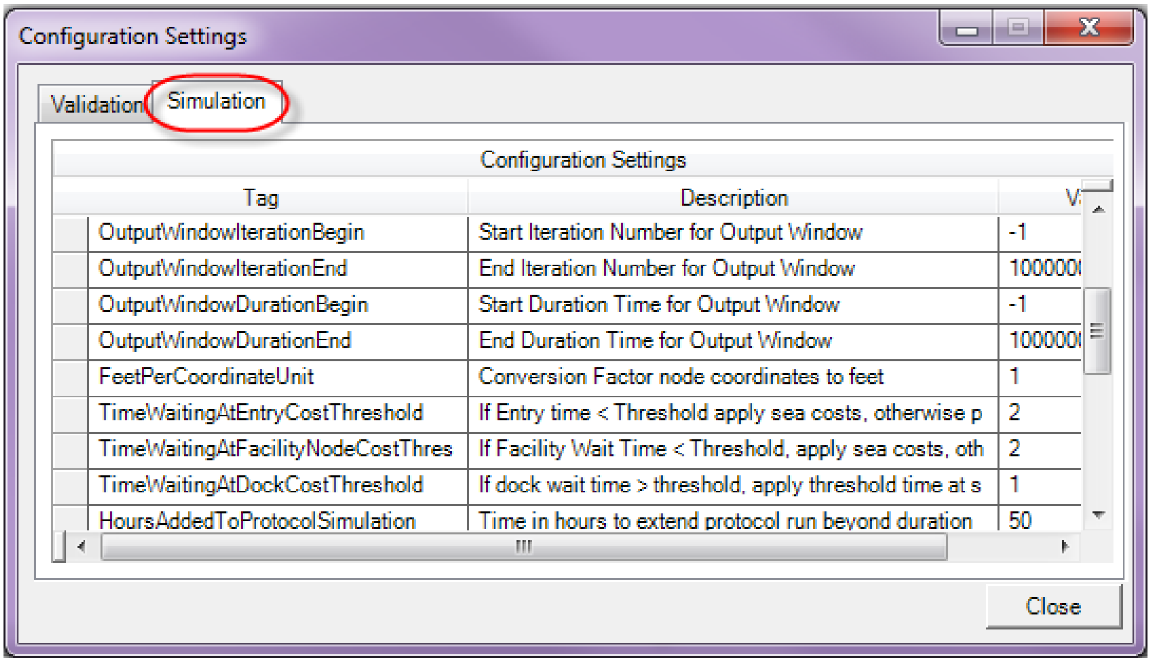

Figure 16: Configuration Settings - Simulation

5.1.3 Print

This function prints HarborSym Data Entry Grids. Page Setup and Print Preview options are available. The Print command prints the Data Entry Grid shown in the Data Entry Pane.

5.1.4 Additional Studies

A list of existing studies is shown within the file menu pillar. The user can change to another study quickly, and avoid using Study Manager, by clicking on the study name.

5.2 View

Two menu items are listed under this menu pillar: "Study Explorer" and "Display Options", as shown in Figure 17. These items control the primary HarborSym screen, which contains the three panes.

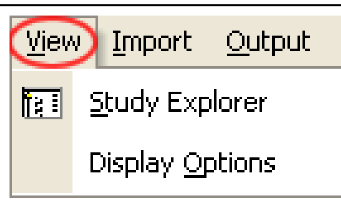

Figure 17: View Menu

5.2.1 Study Explorer

This function returns the three HarborSym panes (Graphics Pane, Navigation Pane and Data Entry Pane) to view. This command is typically used after accessing the Study Manager function.

5.2.2 Display Options

This function calls the Display Options Screen, as shown in Figure 18, which allows the user to adjust the colors and representations used to depict nodes and reaches in the Graphics Pane. Each node type representation can be modified by clicking on the node type on the left side of the Graphic Pane Options Screen, where all node types are listed. Selection of each node type allows the user to select the icon to represent that node type in the Graphics Pane. This screen is used to determine whether node descriptions and node numbers are shown in the Graphics Pane, and how they are represented. The user should consider the complexity of the harbor to be represented when selecting and sizing icons.

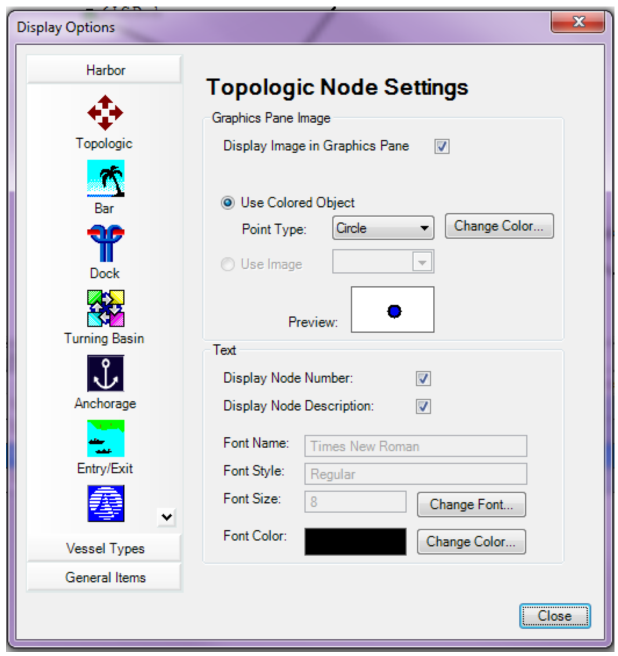

Figure 18: Graphics Pane Options

5.3 Import

Five menu items are available under the Import menu pillar, as shown in Figure 19: "Commodity Transfer Rate "Vessel Docking Time", "Vessel Turning Times", "Vessel Speed in Reach", and "Port Traffic." These selections allow the user to use templates in Microsoft Excel® and import large amounts of data. This feature is most beneficial for projects with a large network or great variety of vessel classifications. Creating the tables in Excel and importing into HarborSym may provide additional efficiencies over direct data entry using the user interface.

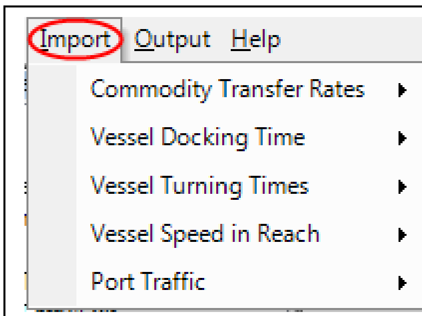

Figure 19: Import Menu

Each item has two options; *Create Lookup Spreadsheet*, and *Import*, as shown in Figure 20. The "Create Lookup Spreadsheet" must be used first. The user will then define a name for the spreadsheet and assign the file to a directory. Additional information about HarborSym templates is available in Appendix A.

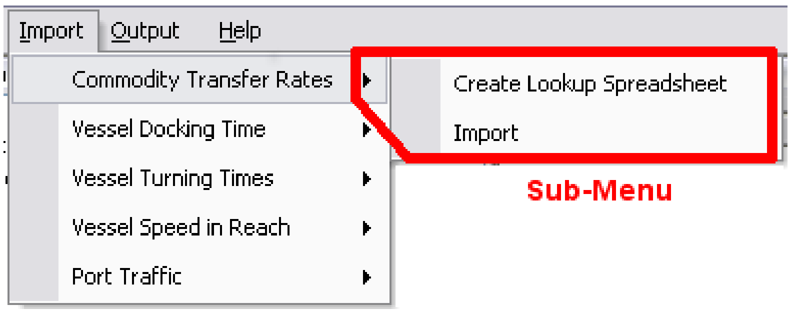

Figure 20: Import Sub-Menu

5.3.1 Commodity Transfer Rate

The Commodity Transfer Rate is the rate at which a commodity, or cargo, is loaded or unloaded from a vessel. A minimum rate, most likely rate, and maximum rate for loading and unloading must be assigned to each commodity category for each vessel classification. The rate is measured in units per hour.

5.3.2 Vessel Docking Time

The Vessel Docking Time is the amount of time a vessel spends docking or undocking. Minimum and maximum vessel docking times, in hours, must be assigned to each vessel classification at each dock.

5.3.3 Vessel Turning Time

The Vessel Turning Time is the speed, in hours, for each vessel type to turn in a turning basin. A minimum, most likely, and maximum turning time must be assigned to each vessel type for each turning basin.

5.3.4 Vessel Speed in Reach

The Vessel Speed in Reach is the speed, in knots per hour, that a vessel can travel in a reach. A light and loaded speed must be defined for each vessel classification for each reach. Vessel operating costs are developed based on vessel speeds, thus the two are directly associated. The user should take care to assure vessel operating costs and vessel sailing speeds are based upon consistent data and assumptions.

5.3.5 Port Traffic

The Port Traffic template imports the vessel call list. This template includes an extensive amount of data on the vessels visiting the harbor and the commodities they transferred. Port traffic is discussed in greater detail in Section 6.6 and Appendix A.

5.4 Output

The Output pillar provides access to simulation output in standard graphs and reports. The three menu options available under the Output menu pillar, as shown in Figure 21, are: "Graphs," "Reports" and "Export." Detailed output files generated during the analysis contain more data about simulations but are not accessed through this file pillar. Output files are stored in the same file directory as the HarborSym study and can be accessed through Windows Explorer. Section 8.3, Viewing Simulations; Section 9, Understanding HarborSym Output; and Appendix C provide details on accessing and interpreting HarborSym output data.

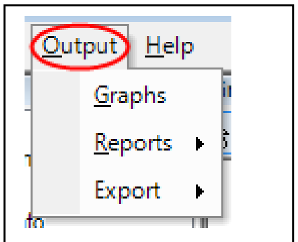

Figure 21: Output Menu

5.4.1 Graphs

The Graph Builder Screen, shown in Figure 22, allows the user to specify the scenario and projects to include in the graph. HarborSym offers six graphical options that can be viewed for any scenario or project. Note that in order for the Vessel Time graph to display the correct average vessel time, the user must select the 'Iteration' output option under Output Controls.

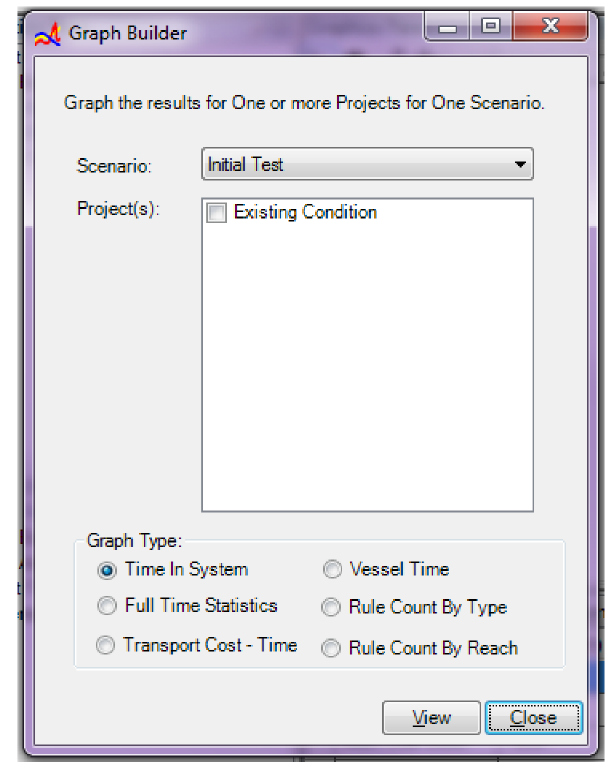

Figure 22: Graph Builder

5.4.2 Reports

Several report options are available, "Project Comparison", "Single Scenario", "Reach Rule Violations", "Transit Rules", "Vessel Class Characteristics", and "Commodity Info", as shown in Figure 23. The Project Comparison Report provides a comparison of multiple scenarios under a single scenario. The Single Scenario Report provides detailed data on the simulation of one scenario with a single project. The Transit Rule Report lists the vessel traffic rules by reach. The Vessel Class Movement Thresholds Report lists the range for each vessel class in each project. The Commodity Info Report lists the Units of Measure and tons per unit of measure for each commodity category.

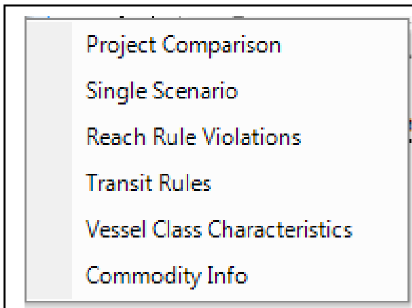

Figure 23: Report Sub-Menu

5.4.3 Export

The export function provides the user with the option to export the vessel call list data within HarborSym. This function is useful because vessel data may be modified or corrected after the original vessel call list is imported into HarborSym. Selecting the Export/Port Traffic option will open a dialog box. The user selects the project desired and specifies a template directory to

save the file. The user then selects "Export". The user is prompted that the export was complete. An *Excel* spreadsheet is exported to the directory specified by the user. The spreadsheet will look exact to the Import Template Spreadsheet, described in Section 5.3.5. The selection of the Export Port Traffic Function from the Output menu is shown in Figure 24.

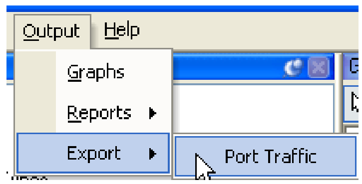

Figure 24: Port Traffic Sub-Menu

5.5 Tools

The Tools pillar provides access to the Bulk Loading Tool (BLT), the Container Loading Tool (CLT), and Combiner VCDB's modules of HarborSym, as shown in Figure 25. Through the BLT module, users can generate synthetic vessel call lists for general bulk carriers for use in future or with-project scenarios in HarborSym. The BLT is introduced in Section 4.1. The CLT module assists users in creating a synthetic vessel call list for containerized vessel for use in future or with-project scenarios in HarborSym. The CLT is introduced in Section 4.2. The Combine VCDB's module, introduced in Section 4.3, is used to combine the VCDB outputs of the BLT and CLT into a single vessel call database to be used by HarborSym. Instructions on how to use the tools are provided in Section 7.

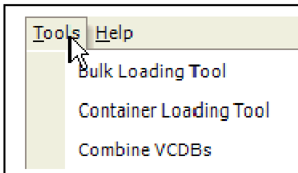

Figure 25: Tools Menu

5.6 Help

The Help menu pillar is shown in Figure 26. The "Help" menu pillar offers the "About" command, which displays the version number of the application. This command will obtain the standard "About" dialog box. The "Contents" option will open a HTML version of the user's guide. The user can browse the guide's outline or index, or search for key words.

Figure 26: Help Menu

5.7 Project Specific Menu Options

A project-specific menu is available by right-clicking on the project name in the navigation tree, as shown in Figure 27. The six menu options are described in the subsections below.

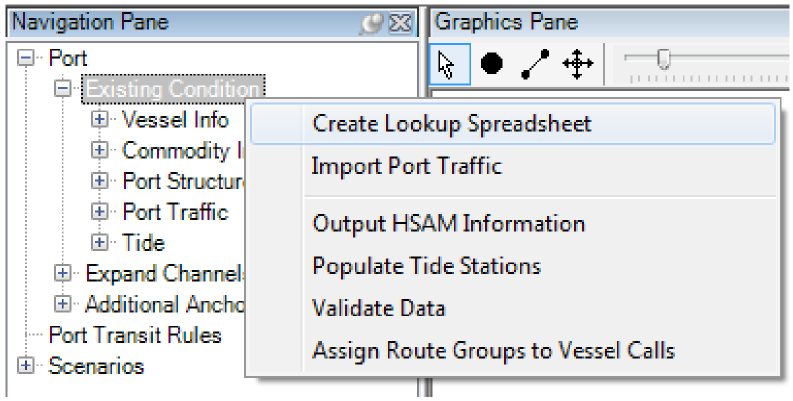

Figure 27: Project Specific Menu Options

5.7.1 Create Lookup Spreadsheet

Selecting the "Create Lookup Spreadsheet" option launches the window to generate a Microsoft *Excel* spreadsheet for importing the vessel call list. This option is also available under the "Import", *Port Traffic* menu option, as discussed in Section 5.3.5. Port traffic is discussed in greater detail in Section 6.6 and Appendix A.

5.7.2 Import Port Traffic

Selecting the "Import Port Traffic" option launches the window to import the Microsoft *Excel* spreadsheet containing the vessel call list. This option is also available under the "Import", *Port Traffic* menu option.

5.7.3 Output HSAM Information

Selecting the "Output HSAM Information" option will generate the files necessary to run the HarborSym Animation Module (HSAM). Section 10 discusses HSAM and how to utilize the output files.

5.7.4 Populate Tide Stations

This option launches the Populate Tide Stations window, which is the first step to adding tidal influence to the simulation. The process for assigning tide and current stations and establishing tidal rules is outlined in Section 6.8.

5.7.5 Validate

The Data Validator is a powerful tool available within HarborSym. Selecting "Validate Data" from the right click menu launches the tool, which is designed to verify the user input data and confirm that all mandatory fields are populated. Section 6.11 discusses the data validation tool.

5.7.6 Assign Route Groups to Vessel Calls

Selecting "Assign Route Groups to Vessel Calls" from the right click menu will automatically allocate a specific route group to each vessel call. Route groups (see Section 3.2.8 for a definition) are required for all vessel calls. As route group assignments are made during the vessel call list import, users do not need to implement this step for imported data. However, if the route group distributions have changed since import or if vessel calls are manually entered through the data entry grids, this action must be executed before HarborSym will process a simulation. The user is given the option to assign all route groups or assign only blanks. If the route group for a given vessel call is known and designated in the Port Traffic spreadsheet, then the user can select 'No' to assign route groups to blank calls only. Note that route group percentages for a given vessel class must equal 100 or an error message will occur and the assignment will be unsuccessful.

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Section 6

Developing a HarborSym Study

This section defines the terms and concepts necessary to develop a HarborSym study. The terms and concepts are defined in a sequence to allow the user to logically and efficiently develop a HarborSym study. Step-by-step instructions to appropriately populate the model with data are provided in the HarborSym training materials. This chapter is divided into subsections, with the content of each grouped by area within the Navigation Pane.

6.1 Studies and Projects

It is key to understand the difference between a study and project, as these terms are used throughout this guide. Studies can have several projects but a project is associated with only one study.

6.1.1 Studies

A HarborSym study is the designation for the overall analysis conducted within the model. A study is limited to one contiguous geographic area, most commonly a single harbor. The study concept provides a broad framework for organizing data for varying conditions within the study area. Each of these differing conditions is termed a project in HarborSym. A study contains at least one project and must have two projects to conduct a comparative analysis.

6.1.2 Projects

A HarborSym project is a definition of a harbor at a specified period in time, including all the physical characteristics of the docks, turning basins, anchorages and reaches within that harbor. The vessel transit rules are part of a project. Projects consist of both the physical layout of the study area and the port traffic; thus, a project must consider the element of traffic demand for a given time period. Projects within a study can have the same vessel call list. If using HarborSym in the framework of USACE planning studies, the first project should represent the current conditions at the harbor (the "existing condition"). HarborSym should be calibrated by comparing the outputs of this project with actual data available from the harbor. Additional projects are created to represent possible harbor improvement projects and varying traffic demand over time. A comparison of simulation outputs from the existing condition project with the future projects will assist the user in understanding the potential changes in transportation costs over time and under different channel configurations.

6.1.3 Study Manager and Study Explorer

The HarborSym Study Manager is a function used to create studies and projects and to navigate between studies. Unless the HarborSym user is working on navigation analyses in multiple locations, the Study Manager function will be used mainly to create new projects within an existing study with which to analyze alternative harbor improvements. The file directories for storing studies and projects are selected in Study Manager. To create a new study, select Study Manager from the File menu. The Study Manager form, as shown in Figure 28: Study Manager, will open.

The form is divided into two portions; fields in the top portion describe the study location, while the bottom portion allows the user to create and manage projects within the study. Specific items in the study description portion include:

- Port Desc: this field should contain a short description of the study port, possibly the harbor name.
- Latitude and Longitude: values entered into these fields should approximate the general geographic position of the study area, such as the center of the harbor or the entrance channel. HarborSym uses this information to determine the sunrise and sunset times, which is necessary for the appropriate application of several transit rules. The longitude values for North America should be negative.
- UTC Offset: this field should contain the Coordinated Universal Time (UTC) adjustment for the study area. For ports along the U.S. east coast, the correct value is (-5); for U.S. west coast ports the value is (-8). As with latitude and longitude, HarborSym uses this information to determine the sunrise and sunset times.
- DST Fields: these fields require information on the application of daylight savings time adjustments. This information is also used to determine the sunrise and sunset times within the model.

The bottom portion of the Study Manager window contains fields enabling the user to create, modify, clone, and delete projects.

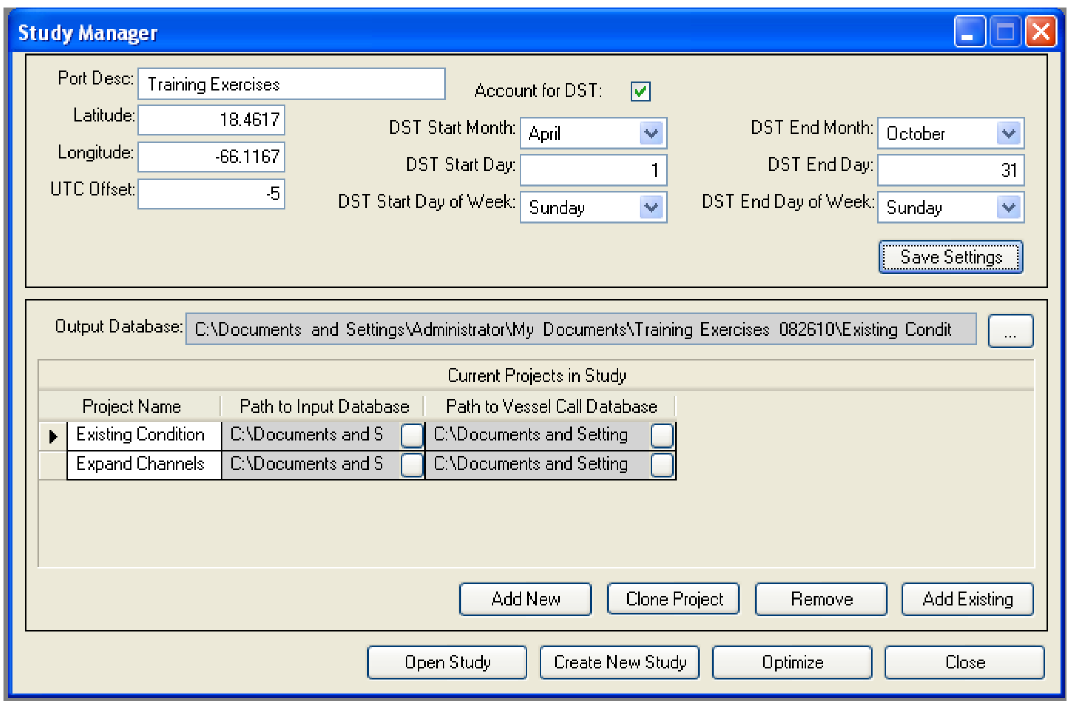


Figure 28: Study Manager

6.1.3.1 Create New Study

Click the Create New Study button. Click the button (...) beside the location field to select the location where files related to this study will be stored. Next, enter the name of the study into the Study Name field and a project name, such as Existing Conditions, into the Project Name field. Click

Create to create the study. Section 3.1 and Table 1: Databases Used In Analysis contain a discussion of the different databases identified in the Study Manager. The Study Manager form can now be closed by clicking on the Close button.

The HarborSym model uses Microsoft *Access*® files extensively and the Study Manager contains an Optimize function that performs the Compact function of Microsoft Access®. Pressing the Optimize button will run this function and may result in a decreased file size for the various Microsoft *Access*® databases supporting the study. Doing so will not impact the data stored within the databases.

6.1.3.2 Accessing a Study

The Study Explorer is used to access the HarborSym user interface after setting or changing project parameters using the Study Manager. To access the study selected in the Study Manager, select "Study Explorer" under the "View" menu option.

6.2 The Node Network

The node network represents the harbor and consists of nodes and reaches. In many studies, most aspects of the node network will remain unchanged in the without- and with-project conditions. Unless new channels or docks are being considered, the node network layout will not change. All docks, turning areas, harbor entrances and channels need to be mapped in the node network at the onset. It is recommended to include future features in the existing condition network to ensure consistency among stable elements of the network. For example, if a proposed improvement includes adding an anchorage, it is recommended to build the network with a topologic node in the proposed anchorage location for all projects, including the existing condition. In with-project conditions, the node type can be changed to "Anchorage" to reflect the proposed facility. Such an approach helps ensure the only change between the two projects is the additional anchorage. Specific characteristics of network features, such as channel width or dock depth, can vary among the projects within a study.

6.2.1 Port Structures

Port Structures are one of the five main headings under each project name in the Navigation Pane. Port Structures consist of nodes and reaches. The types of nodes are listed in the Navigation Pane under Port Structures. Nodes represent points in the harbor. Nodes are specified by type to include: docks, turning areas, anchorages, entry/exit points and topologic points. Reaches are also listed under Port Structures in the Navigation Pane. Reaches represent channels between nodes in the harbor. Vessels transit the harbor reaches from the harbor entrance to their destination dock.

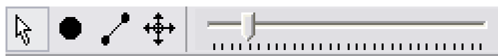
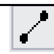
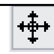
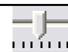
6.2.2 Mapping Nodes and Reaches

A graphical representation of the harbor network is created in HarborSym by using a computer mouse to insert nodes into a blank Graphics Pane. This technique allows for the easy positioning of nodes so that they are a visual representation of their relative positions to each other. Optimal mapping of nodes and reaches requires proportional distancing of nodes. However, the HarborSym graphics pane is not currently geo-referenced so precise relative placement between nodes is not possible or necessary. The distances between nodes used in the simulation are entered independently as reach lengths, but the reach lengths input into the data entry grid are not reflected in the Graphics Pane.

To map the diagram, use the Node and Reach Mapping Tools as shown in Table 3. To add a new node, click on the Add a New Node button with the left mouse button. Click on the blank Graphics Pane where this node is to be located. Place other nodes on the diagram so that all docks, entry/exit points,

turning/holding areas and topological points are represented. Once this is complete the user should connect the nodes using reaches. Select the Add a New Reach tool, click on a node in the Graphics Pane, and then click on another node. This will connect the two nodes with a reach. Continue until all reaches are represented in the Graphics Pane. After the diagram is complete, select a type for each node by right clicking on each node and selecting the appropriate type.

Table 3: Node and Reach Mapping Tools

Map Options		
		
The following map options are available:		
Normal Selection:		Negates the selection of other map options
Add a New Node:		Places node symbols on the screen
Add a New Reach:		Places reach symbols on the screen
Move an Item:		Moves Node and Reach symbols on the screen
Zoom in/Out 100%:		Zoom Function

6.2.3 Adding Background Image

Although the HarborSym Graphics Pane is not geo-referenced, a background image may be helpful in developing a reach-node network. Any image in .bmp, .jpg, or .gif format can be displayed by right clicking in the Graphics Pane and selecting "Add Background Image". Recommended images include maps or harbor system schematics. Adding the image before building the network can assist in establishing reasonably relative distances between nodes. The image can also be useful in providing context when communicating model concepts and findings to stakeholders.

6.2.4 Defining Nodes

Node types (topologic, dock, turning basin, anchorage, or entry/exit) are defined in the Graphics Pane by right-clicking on the node and selecting the desired structure. Once a type is assigned to the node, HarborSym populates default values in a row in the corresponding Port Structure Data Entry Grid. The default values include a generic description and ID(#).

To name each node, click the plus icon beside Port Structures in the Navigation Pane and select Topologic as shown in Figure 29. Select the Description field for each node and provide a more meaningful name in the Data Entry Grid.

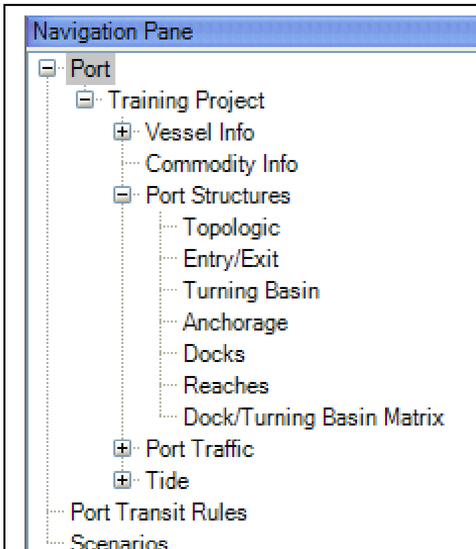


Figure 29: Node Descriptions

6.2.4.1 Topologic Points

All nodes are initially topologic nodes by default, but can be changed to represent functional nodes (docks, anchorages, etc.). Often, harbor configurations require

nodes that are not functional nodes. These nodes might represent the beginning of a new channel depth or width, or may be a junction point between the main channel and a branch channel. The representation of such elements should be made with a topographic node. These nodes do not require data entry for measurements. The descriptions entered in the topologic tab will appear in the Graphics Pane for all node types. Node descriptions must also be entered in the specific node type data entry grids. For example, a node type may be changed from topologic to dock. This node will still appear in the Topologic data entry grid. The description entered in the Topologic grid will display in the graphics pane, even after the node type has been changed to dock. However, the user must also enter the node description in the Dock data entry grid in order to have the information displayed in the dock tables. This also applies to turning basins, anchorages, and entry/exit points.

6.2.4.2 Node Numbering and Deletion

A delete node option is available by right clicking on the node in the Graphics Pane. When this option is selected, HarborSym will launch a window to confirm the deletion. If the delete node is confirmed, all data associated with the node will be removed from the model and cannot be restored.

If nodes are deleted from the system, users must verify that sequential ID numbers are associated with the remaining nodes of a given type. The values in the ID(#) field of the specific node type table and also the topologic node table are automatically populated when the node is created. If a node is removed from the network, the auto populated numbers must be manually adjusted to ensure sequential ordering. For example, a hypothetical three dock system contains nodes named Dock 1, Dock 2, and Dock 3. In this system, these dock names have corresponding ID(#) values of 1, 2, and 3, respectively. If Dock 2 (with ID(#) 2) is deleted, the remaining ID(#) fields are no longer sequential. The ID(#) field for Dock 3 must be updated manually to read 2.

The requirement for sequential numbering of ID fields applies universally throughout the model. Failure to maintain sequential ID values will prevent HarborSym from processing a simulation. The Data Validator (Section 6.11) can review the sequential numbering prior to processing a simulation to highlight potential errors in the system setup.

6.2.5 Entering Turning Basin, Dock, and Anchorage Data

The specific characteristics related to each node can now be defined. Each node can be selected in the graphics pane, which will guide the navigation pane and data entry pane to the correct data entry form.

6.2.5.1 Docks

Docks are nodes where vessels load and unload commodities. Docks are capable of transferring specific commodity categories as selected by the user. The dock description is the name that will appear in the Navigation Pane and should match the corresponding node description in the Topologic table. In a typical large harbor, the user will need to aggregate docks to allow representation in the node network. For example, a harbor with 100 docks might be represented with 10 docks in the node network. The determination to aggregate docks should consider geographic proximity, operating practices (e.g., commodity transfer rates), and the types of commodities and vessels serviced.

The dock data entry grid contains three tabs: Dock; Vessel Docking Time; and Commodity Transfer Rate. Within the Dock tab, all fields are mandatory. The Default Turning Basin field is populated from all pull down menu, which is empty until turning basins have been added to the network.

Vessel Docking Time Tab

The rows in the Vessel Docking Time tab will be populated automatically when vessel types and classes are entered into the database. The user must provide docking and undocking times, in hours, for all vessel classes that will visit the dock. Null values are acceptable for vessel classes that do not visit the dock. The data grid is shown in Figure 30. The user can import this data into HarborSym through a template if desired, rather than manually completing the data grid. This is done by first selecting Import/Vessel Docking Time/Create Template from HarborSym's main menu. Once the template spreadsheet is completed, the user imports the data into the project by selecting Import/Vessel Docking Time/Import from HarborSym's main menu.

Dock | Vessel Docking Time | Commodity Transfer Rate

			Docking Time (hrs)		UnDocking Time (hrs)	
Dock	Vessel Type	Vessel Class	Min	Max	Min	Max
Container Dock	Tanker	Tanker - Small				
Container Dock	Tanker	Tanker - Large				
Container Dock	Bulker	Bulker - Small				
Container Dock	Bulker	Bulker - Large				
Container Dock	Container	Container - Small	1.4	1.6	0.5	0.7
Container Dock	Container	Container - Large	1.4	1.6	0.5	0.7

Figure 30: Vessel Docking Time Tab

Commodity Transfer Rate Tab

The amount of time spent transferring commodities (cargo) is dependent upon the dock, the vessel type, and the commodity category. A minimum, most likely, and maximum loading and unloading time should be entered. The rows in the Commodity Transfer Rate Time tab will populate automatically when vessel types, classes, and commodity categories are entered into the database. The data grid is shown in Figure 31: Commodity Transfer Rate Tab. Loading and unloading rates are mandatory for all commodity types that are exchanged at the dock. To filter the rows, click on the column heading in the Data Entry Pane. The user can import this data into HarborSym through a template if desired, rather than manually completing the data grid. This is done by first selecting Import/Commodity Transfer Rate/Create Template from HarborSym's main menu. Once the template spreadsheet is completed, the user imports the data into the project by selecting Import/Commodity Transfer Rate/Import from HarborSym's main menu.

Dock | Vessel Docking Time | Commodity Transfer Rate

			Loading Rate (units/hour			Unloading Rate (units/ho		
Dock	Vessel Type	Commodity Category	Min	Most Likely	Max	Min	Most Likely	Max
Dock 1	Containership	Containers	250	250	250	250	250	250
Dock 1	Bulker	Metals	750	750	750	750	750	750
Dock 1	Bulker	Liquid Bulk	2500	2500	2500	2500	2500	2500

Figure 31: Commodity Transfer Rate Tab

6.2.5.2 Turning Basins

The terms turning basin and turning area are used interchangeably in HarborSym. Turning basins are nodes where vessels turn. The Turning Basin data entry grid, shown in Figure 32, stores the turning basin description, the vessel capacity, whether the turning area blocks the channel, and the VSU capacity. The capacity field refers to the maximum number of vessels that can simultaneously utilize the turning basin, while the VSU capacity relates to the total abstracted vessel size units that can be accommodated. During simulations, HarborSym considers both values when determining if a turning basin is free for use. The user selects whether vessels turn in the turning basin before or after reaching their destination dock, or when the vessel is heaviest or lightest during its vessel call in the Docks Data Entry Grid.

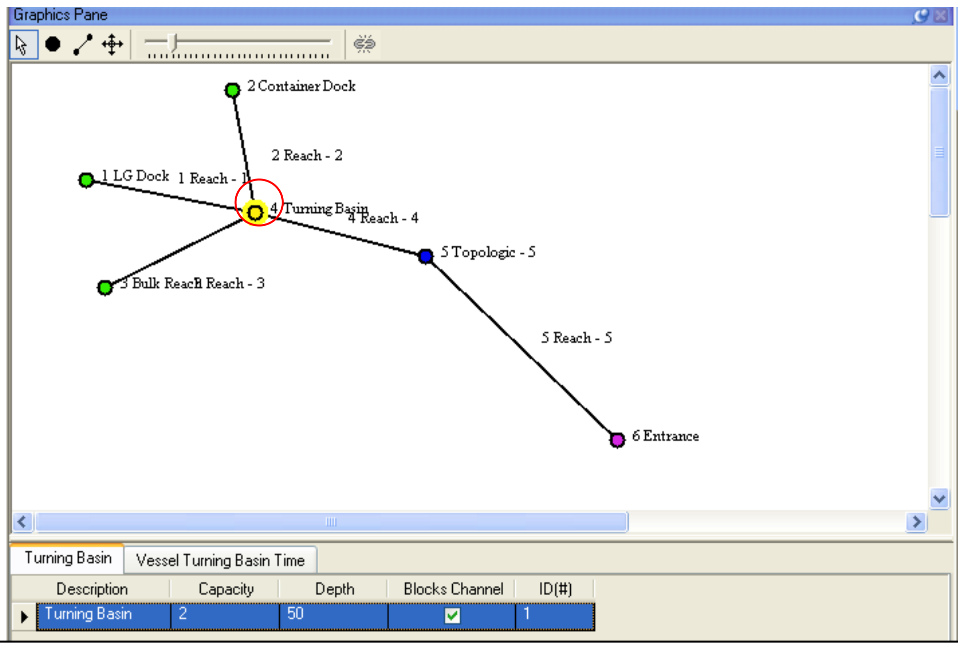


Figure 32: Turning Basin Data Entry Grid

Vessel Turning Basin Time Tab

In the Vessel Turning Basin Time tab, shown in Figure 33, users enter the minimum, maximum, and most likely turning time in hours by vessel type. These fields are mandatory. The user can import this data into HarborSym through a template if desired, rather than manually completing the data grid. This is done by first selecting Import/Vessel Turning Times/Create Template from HarborSym's main menu. Once the template spreadsheet is completed, the user imports the data into the project by selecting Import/Vessel Turning Times/Import from HarborSym's main menu.

Turning Basin | Vessel Turning Basin Time

	Turning Time (hrs)		
Vessel Type	Min	Most Likely	Max
Tanker	0.25	0.5	1.25
Bulker	0.25	0.5	1.25

Figure 33: Vessel Turning Basin Time Tab

6.2.5.3 Entry/Exit Points

Entry/exit points are nodes where vessels enter or exit the harbor. A name should be entered for at least one Entry/Exit point. To access data for Anchorages, the user can either select the desired anchorage from the Graphics Pane or select Anchorage from the Navigation Pane.

6.2.5.4 Anchorages

Anchorages are nodes where vessels can wait before entering the next reach. Anchorages exist as potential stopping points within a leg, and are not considered endpoints of legs. Anchorages have capacity limits defined by both maximum vessels and VSUs. Although the field "Blocks Channel" is available in the data entry grid, this feature is not presently implemented for anchorages, only for turning areas. For each anchorage, the user must provide a description, capacity, depth, VSU capacity, and indicate whether the anchorage blocks the channel. To access data for Anchorages, the user can either select the desired anchorage from the Graphics Pane or select Anchorage from the Navigation Pane.

6.2.6 Defining Reaches

Information must be entered defining the physical characteristics of each reach. To complete this task, select Reaches in the Navigation Pane and the Data Pane will provide grids for entering data as shown in Figure 34. The user can highlight particular reaches and their corresponding rows in the Data Entry Grid by clicking the plus icon beside Reaches in the Navigation Pane and then selecting a particular reach. The reach will then be highlighted in the Graphics Pane and the row of corresponding data will be displaying the Data Entry Grid. Likewise, the user can select a reach in the Graphics Pane and the corresponding row in the Data Entry Grid will be highlighted.

The length, width, depth, and description can be entered for each reach in the Data Entry Grid. Units should be expressed in feet. In addition, if safety zones will be active in any of the reaches, the user should make the designation by selecting the checkbox available for the reach. If there will be any ships carrying safety zone commodities that require a safety zone through a particular reach, the user should select the check box beside Reach Safety Zone Active for that particular reach.

The data entry grid for each reach contains two additional tabs for entering data on vessel speed in reach and transit rules.

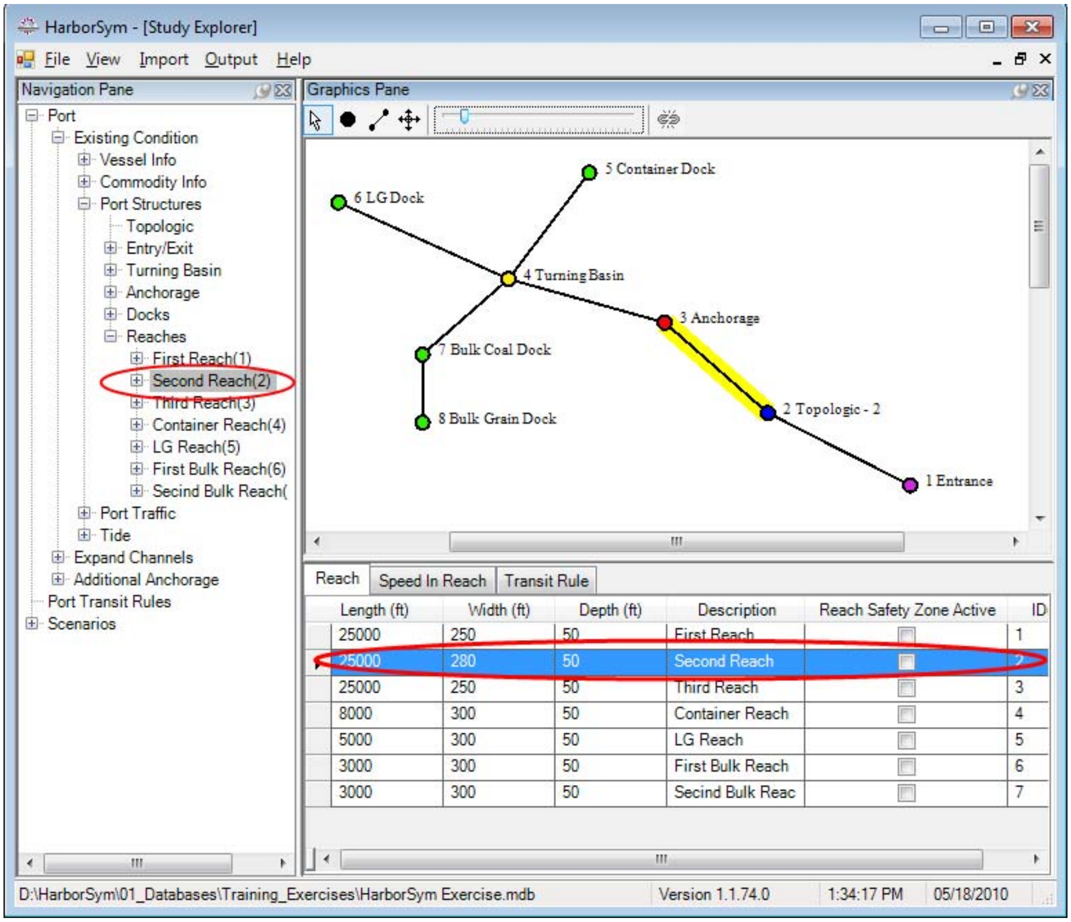
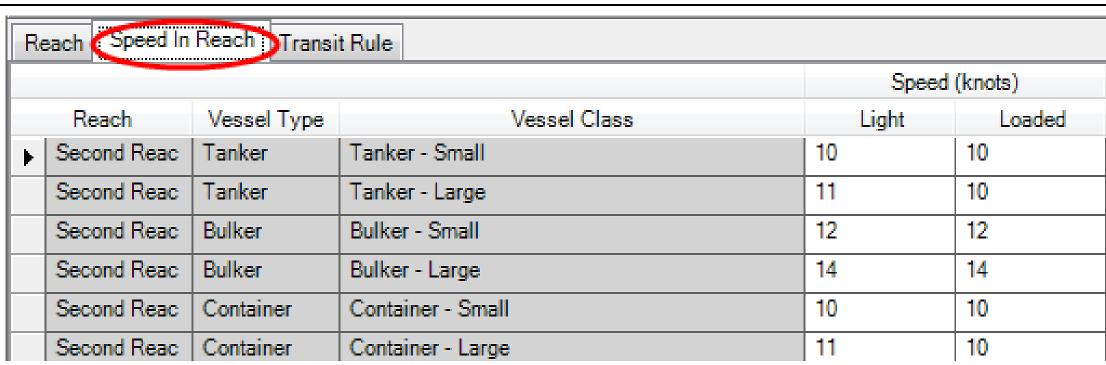


Figure 34: Reach Information

Speed in Reach Tab

The rows in the Speed in Reach tab, shown in Figure 35, are automatically generated with all the populated vessel classes. Light and loaded speeds, in knots per hour, are mandatory fields for all vessel classes that will traverse a given reach. Vessel operating costs are developed based on vessel speed. Thus, the user should take care to assure vessel operating costs and vessel sailing speeds are based upon consistent data and assumptions.



			Speed (knots)	
Reach	Vessel Type	Vessel Class	Light	Loaded
Second Reac	Tanker	Tanker - Small	10	10
Second Reac	Tanker	Tanker - Large	11	10
Second Reac	Bulker	Bulker - Small	12	12
Second Reac	Bulker	Bulker - Large	14	14
Second Reac	Container	Container - Small	10	10
Second Reac	Container	Container - Large	11	10

Figure 35: Speed in Reach

Transit Rule Tab

Individual reach transit rules are entered on the Transit Rule tab. The user should select the desired rule type from the predetermined list in the "Type" pull-down menu. Parameters to customize the rule are entered into the appropriate fields; the mandatory fields will be highlighted blue once the rule type has been selected.

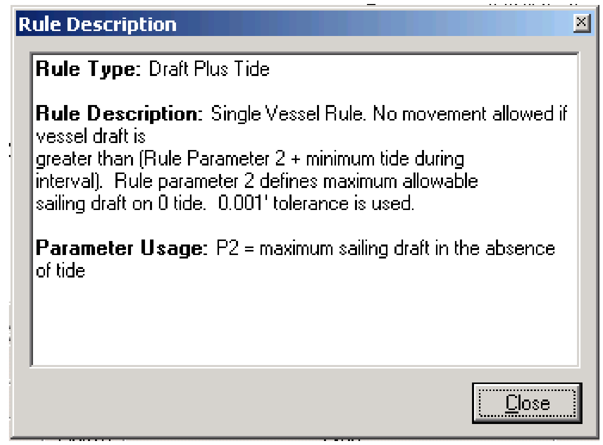


Figure 36: Rule Description Window

Selecting the ( ) button in the "Desc" field will launch a pop-up window describing the selected reach and identifying which fields must be populate, as shown in Figure 36. For example, if the rule type "Draft Plus Tide" is selected, a testing vessel will be restricted from moving if its draft exceeds the user defined maximum sailing draft plus the minimum tide during the sailing interval. The user must enter the applicable maximum sailing draft in the data entry grid, under Parameter 2.

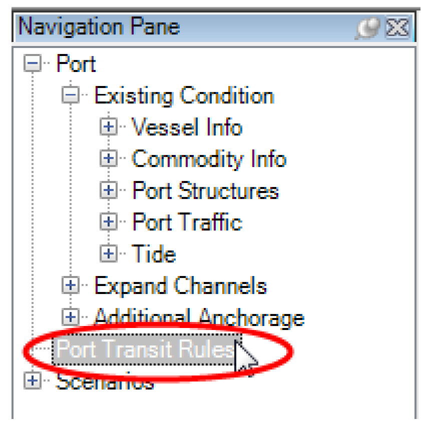


Figure 37: Port Transit Rules

To enter transit rules that apply to the entire port, the user should select Port Transit Rules in the Navigation Pane as shown in Figure 37. A specific type of transit rule, the application of safety zones, is described in more detail in Section 6.10.

6.3 Vessels

Vessels are the ships that visit the harbor. Vessel types and vessel classes are defined by the user before the vessel call list is entered into HarborSym. Vessel classes are subsets of vessel type. An extensive amount of data must be entered to describe the vessel class characteristics, such as physical characteristics, sailing speeds, types of commodities carried, sailing costs, and associated route groups.

HarborSym provides flexibility in defining vessel types and vessel classes, but the user should consider the availability of data when defining vessel types and vessel classifications. The user must also consider the characteristics of the future fleet and create vessel types and classes that capture the possibility of large vessels calling the port. This is especially important if the Loading Modules will be used to generate a synthetic vessel call list for the future. Classifications for containerships should also be considered if the CLT will be utilized.

6.3.1 Vessel Types

Vessel types must be defined by the user for each HarborSym study. It is generally recommended to follow maritime convention when establishing vessel classes. Examples of vessel types include tankers, bulkers, general cargo ships and containerships. To create vessel types and assign parameters to each vessel type, the user should click the plus icon beside Vessel Info in the Navigation

Pane. Next, select Vessel Types in the Navigation Pane. The user can now enter the vessel types and select the appropriate classification options in the Data Entry Pane as shown in Figure 38.

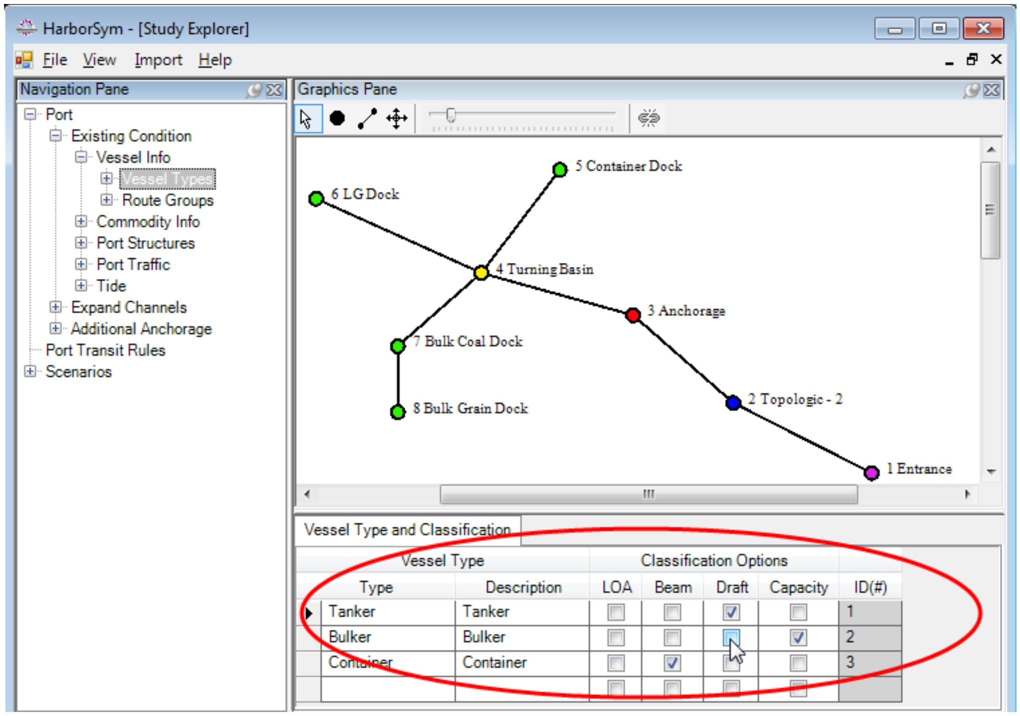


Figure 38: Vessel Type Information

6.3.2 Vessel Classifications

Vessel classes are subgroups of vessel types and are the basis for HarborSym data entry. The average speed transiting the harbor, the docking and undocking times, the rate at which commodities are loaded and unloaded are dependent upon vessel classifications. Vessel classes are established by grouping unique vessels frequenting the study area into categories based on one or more defining measurements (LOA, Beam and Capacity). While the classes are defined based upon the physical characteristics, vessels within a class must also carry commodities appropriate to the class, and have approximately equal sailing speeds, drafts, and operating costs. The following subsections outline the five vessel class tabs available for data entry.

It should be noted that when the CLT will be utilized for generating a synthetic vessel call list, the vessel classes should be generally aligned with the assumptions inherent in the CLT (vessel type of Containership and Vessel Classes: SubPanamax, Panamax, PostPanamax Gen1, and PostPanamax Gen2). See Section 7.2.4.10 for additional details.

Vessel Type and Classification Tab

This tab establishes the parameters for bracketing vessels by class. The options for class definitions are all based upon the vessel physical dimensions. The measurements used can differ between vessel classes. Also, more than one measurement can be used to define vessel classifications. In an example study, for instance, tankers may be assigned to classes based upon their design draft. However, in the

same study, containerships may be classified based on the vessel beam and length overall. The options for classification include:

- LOA – length overall of the vessel, expressed in feet
- Beam – width of the vessel, expressed in feet
- Draft – the design draft of the vessel (not the sailing draft), expressed in feet
- Capacity – the amount of commodities (cargo) a vessel can carry, measured in NRT (net registered tons), GRT (gross registered tons) or DWT (deadweight tons). ***Note: if the BLT will be used to develop future call lists, DWT must be used to define capacity.***

When the user imports port traffic into the study, HarborSym identifies each unique vessel in the dataset and assigns a vessel type based on the criteria specified in the Vessel Type and Classification tab, the vessel type attributes, and the attributes of each vessel.

Vessel Class Definition Tab

To define vessel classes within vessel types, click the plus icon beside Vessel Types and select a vessel type as shown in Figure 39. Alternatively, a vessel type can be selected in the Vessel Type and Classification tab by highlighting the desired row. The user should select the Vessel Class Definition Tab after choosing the desired vessel type.

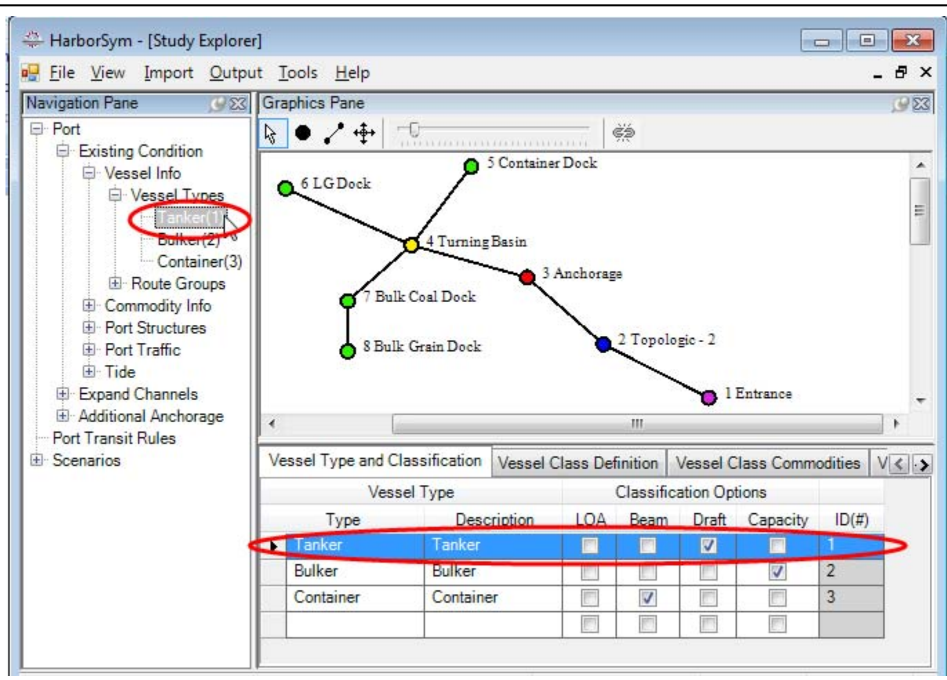


Figure 39: User Selection of Vessel Type Classification

The Vessel Type field is automatically populated and cannot be changed by the user, as shown in Figure 40. Default values are provided for Description and Short Description based upon the vessel type description. These fields can be modified to reflect more appropriate descriptions. For example, the vessel type "Tanker" may have two vessel classes: "Tanker Large" and "Tanker Small", with these

names entered into the descriptions fields. The short description field appears in select output files and must be populated. If the vessel class is given priority access in the harbor, select the "Priority Vessel" check box.

Vessel Class Definition | Vessel Class Commodities | Vessel Class Attributes | Vessel Class Route Group

				Capacity		Draft	
Vessel Type	Description	Short Description	Priority Vessel	Min	Max	Min	Max
Tanker	Tanker - Small	SmTanker	☐	0	0	0	25
Tanker	Tanker - Large	Tanker - Large	☐	0	0	26	50
Tanker	Tanker	Tanker	☐				

Figure 40: Vessel Class Definition Tab

Of the remaining fields, only those which are used in the vessel type classification must be populated for HarborSym. However, the vessel class definitions are used by the BLT to assess the validity of generated vessels. Thus, if the BLT will be used to generate a synthetic vessel call list then all fields in the Vessel Class Definition tab must be completed.

The user determines the characteristics of classification in the Vessel Type and Classification tab. Minimum and maximum values are required to bracket the vessel classes. The appropriate assignment of vessels into vessel classes is critical for the model to function properly. Several transit rules are applied based on vessel class; if unique vessels are incorrectly assigned to vessel classes the transportation costs may be inaccurate. During the vessel call list import, HarborSym assigns unique vessels to specific vessel classes based upon the characteristics defined in this tab. Additional information in Section 6.6 describes the procedures for vessel classification and the process for managing unique vessels that may fall within multiple overlapping categories.

Initially, only one row will appear in the Vessel Class Definition tab. Additional rows are generated automatically once the user edits the previous row.

Vessel Class Commodity Tab

In the Vessel Class Commodities Tab, shown in Figure 41, the user should identify which commodities can be carried on each vessel class. Multiple commodities can be selected. The rows of this tab are automatically populated with the vessel classes entered in the Vessel Class Definitions Tab. The commodity categories, shown across the column headings, are automatically populated with the categories entered in the Commodity Category tab. Thus, the vessel class commodities cannot be assigned until the commodity categories have been defined.

Vessel Class Definition | Vessel Class Commodities | Vessel Class Attributes | Vessel Class Route Group

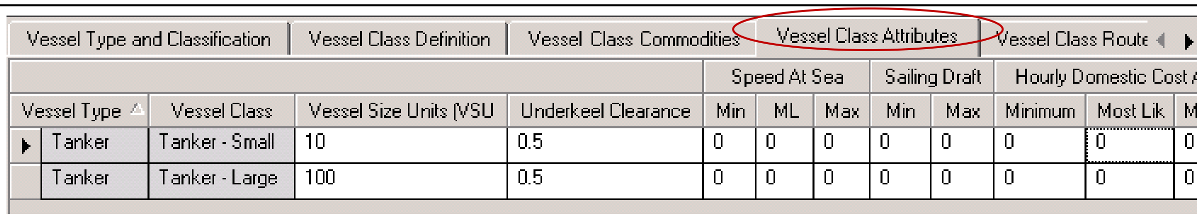
Vessel Type	Vessel Class	Liquefied Gas	Coal	Grain	Mechanical Parts	Electronic De
Tanker	Tanker - Small	☑	☐	☐	☐	☐
Tanker	Tanker - Large	☑	☐	☐	☐	☐

Figure 41: Vessel Class Commodities Tab

Vessel Class Attributes Tab

The Vessel Class Attributes Tab has data entry fields for various descriptors that are unique by vessel class, as shown in Figure 42. The required fields are described below.

- Vessel Size Units (VSU): The value in the VSU field represents an abstract unit of measure designed to account for multi-dimensional vessel sizes. Additional information on VSU usage is available in Section 3.2.5.
- Underkeel Clearance: Underkeel clearance is the distance required between the keel, the lowest part of the vessel, and the harbor floor, expressed in feet. The default value for underkeel clearance is 0.5 feet.
- Default TPI: this field is not mandatory. Values populated here are used by the BLT when no TPI regression is available. See Section 7.1 for details. TPI should be entered as tons per square inch.
- Speed at Sea: This field is not used in widening version calculations. This value is used to calculate voyage costs, including ocean legs. If the at sea mileage will not impact the study results, a placeholder value of 1 can be entered (the field must be populated). Speed at sea should be entered as knots, or nautical miles per hour.
- Sailing Draft: The maximum / minimum sailing drafts are used in the draft adjustment calculations, as described in Section 3.3.2. Sailing drafts should be expressed in feet.
- Hourly Operating Costs: Minimum, maximum, and most likely hourly operating costs must be provided for HarborSym to estimate transportation costs. The operating costs must be defined by vessel status (at sea or in port) and also by vessel flag (foreign or domestic). Operating costs are described in Section 3.2.5.

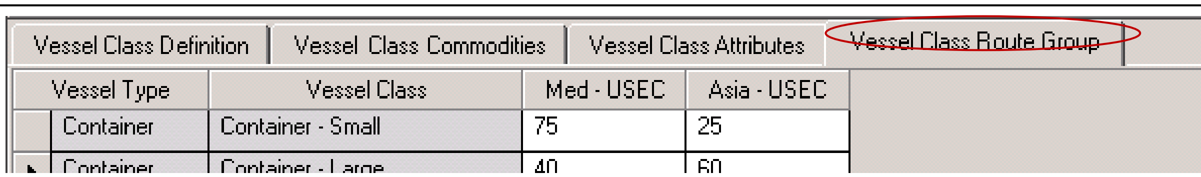


Vessel Type	Vessel Class	Vessel Size Units (VSU	Underkeel Clearance	Speed At Sea Min	ML	Max	Sailing Draft Min	Max	Hourly Domestic Cost Minimum	Most Lik	M
Tanker	Tanker - Small	10	0.5	0	0	0	0	0	0	0	0
Tanker	Tanker - Large	100	0.5	0	0	0	0	0	0	0	0

Figure 42: Vessel Class Attributes Tab

Vessel Class Route Group Tab

As shown in Figure 43, the Vessel Class Route Group tab allows the user to establish the distribution of vessel calls within a vessel class that travel in previously identified route groups (see Section 6.4 for further details on route group creation). The values are percentages and will be divided by 100 internally within the model. Thus, if 25% of a vessel class sails an Asia to U.S. East Coast circuit, “25” should be entered into the data grid. Note that route group percentages must equal 100 for given



Vessel Type	Vessel Class	Med - USEC	Asia - USEC
Container	Container - Small	75	25
Container	Container - Large	40	60

Figure 43: Vessel Class Route Group Tab

vessel class or an error will occur when assigning route groups to vessel calls.

The rows of the Vessel Class Route Group tab will automatically populate with the user-defined vessel classes of the selected vessel type. The column headers will automatically populate with the user-defined route groups. Thus, this tab cannot be populated until route groups have been established.

For widening studies, the fields in this table are not mandatory for proper model functioning. The default route group can be used with 100 for all vessel classes. If the BLT will be used to generate a future synthetic vessel call list, then the future condition for vessel class and route group must be specified within this tab for the project.

6.4 Route Groups

Route groups are necessary in HarborSym for channel deepening studies, as described in Section 3.2.8. Information on route groups can be entered by selecting "Route Groups" under "Vessel Info" in the Navigation Pane, as shown in Figure 44. The Data Entry Pane will display a grid for entering data required for route groups, as shown in Figure 45.

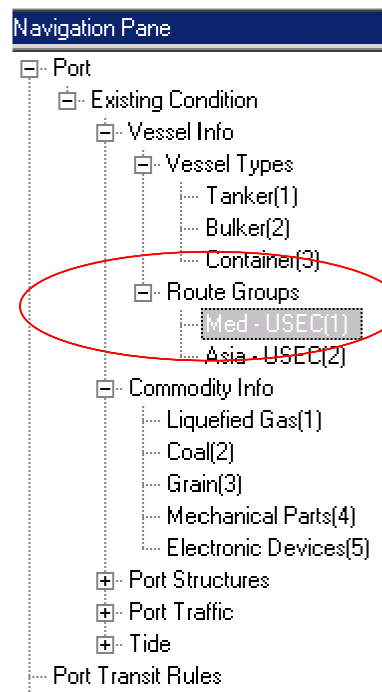
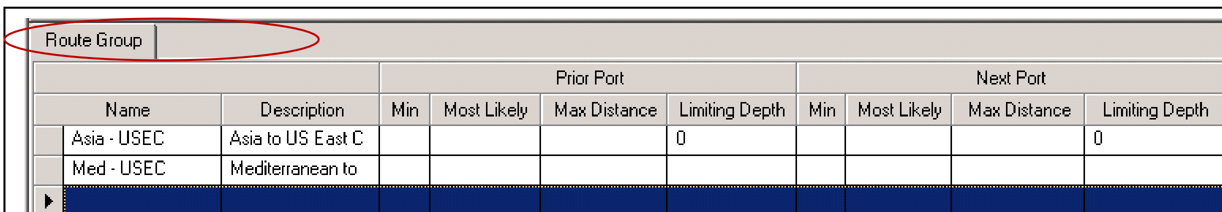


Figure 44: Route Groups

For each route group, the user must provide minimum, most likely, and maximum distances and limiting depth for the prior and next ports of call. The user should be certain to assess the potential limiting depth under future conditions considering the future planned expansion of the Panama Canal. "Additional Sea Distance" can also be defined with a triangular distribution to address any sea sailing not covered in the prior and next port of call fields. All distances should be entered in nautical miles and should consider a reasonable circuit for each group. The A-DAPP provides the Additional Sea Distance for a given Route Group, see the A-DAPP User's Guide for details. Region-to-region distances can be used as a starting point for estimating the distance from the port of study to prior and next port. The National Geospatial Publication 151 is an additional source for port-to-port sailing distances.

For widening studies the distance fields in this table are not mandatory for proper model functioning. The limiting depths must be populated with values greater than the limiting depth of the study harbor.


Route Group

		Prior Port				Next Port			
Name	Description	Min	Most Likely	Max Distance	Limiting Depth	Min	Most Likely	Max Distance	Limiting Depth
Asia - USEC	Asia to US East C				0				0
Med - USEC	Mediterranean to								

Figure 45: Route Group Tab

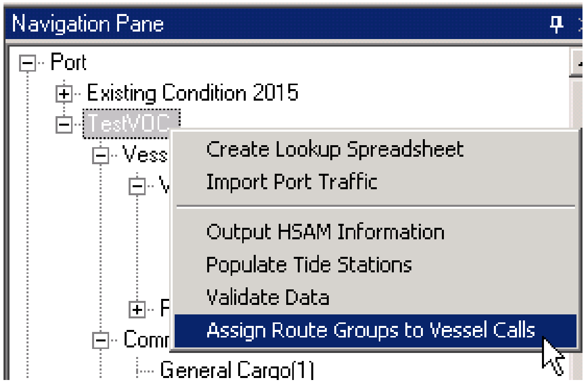


Figure 46: Assignment of Route Groups

Route groups must be assigned to individual vessel calls. The A-DAPP provides this information. A-DAPP data can then be combined with WCSC data using the W-DAPP and exported in a format compatible with the Port Traffic import spreadsheet used by HarborSym. If a vessel call list is imported using the HarborSym import function, the user will be asked whether to assign Route Groups to all calls or to calls with a blank Route Group only. If a vessel call list has been manually entered or modified after import, users can assign route groups by right-clicking on the project name and selecting “Assign Route Groups to Vessel Calls”, as shown in Figure 46.

Note that route group percentages must equal 100 for given vessel class or an error will occur when assigning route groups to vessel calls. After the assignment is complete, HarborSym provides a confirmation message. Note that route group percentages must equal 100 for given vessel class or an error will occur when assigning route groups to vessel calls

6.5 Commodities

Commodities are the cargo that vessels transfer at docks in the harbor. Commodities are defined into categories based upon the available manifest data. The weight of each commodity category is input in tons per unit of measure. These commodity weights determine the draft of vessels exiting the harbor. Commodity categories are also used to establish transfer rates (vessel loading and unloading rates) for vessels at docks.

6.5.1 Commodities

To define the desired commodity categories for a project, select Commodity Info in the Navigation Pane as shown in Figure 47. The user can enter the commodity category description, units of measure and tons per unit for each commodity category as shown in Figure 48. The user can choose between four programmed commodity units: Tons, Containers, Automobiles, and Passengers. If the unit of

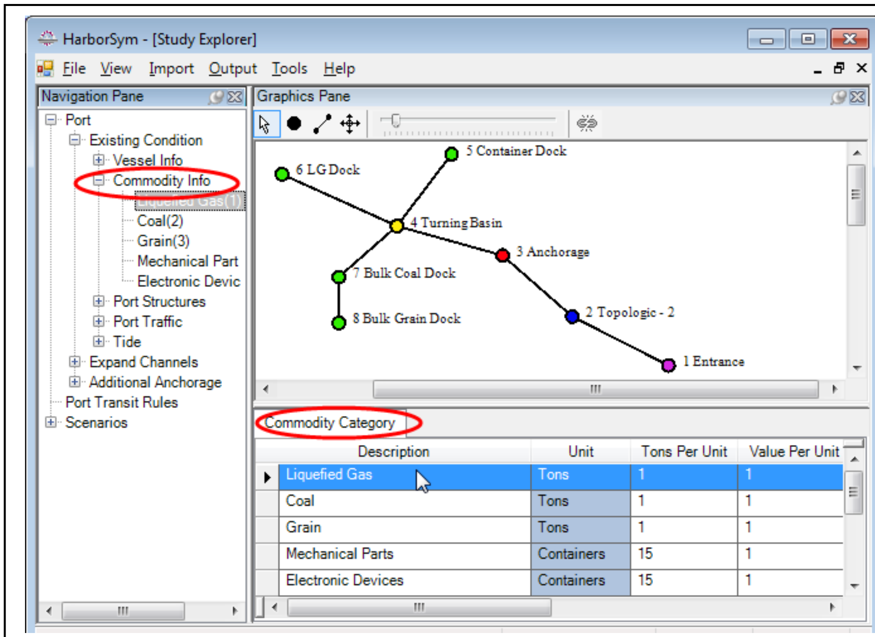
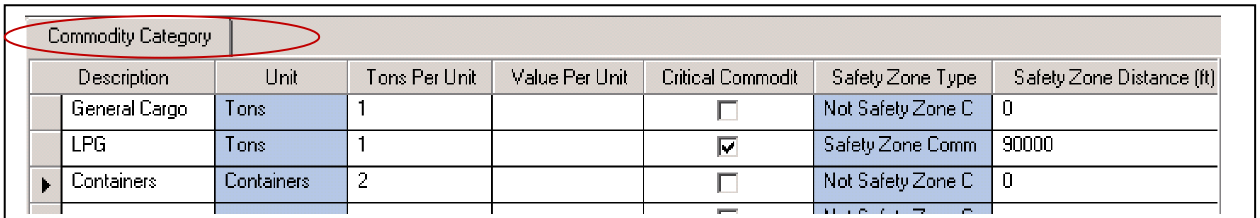


Figure 47: Commodity Information

measure is “Tons” the value in the “Tons Per Unit” field should be 1. If containers, automobiles, or passengers are selected as the unit of measure, a value to convert the unit into tons must be provided. For the CLT, commodities must be in Tons.


Commodity Category

Description	Unit	Tons Per Unit	Value Per Unit	Critical Commodit	Safety Zone Type	Safety Zone Distance (ft)
General Cargo	Tons	1		☐	Not Safety Zone C	0
LPG	Tons	1		☑	Safety Zone Comm	90000
Containers	Containers	2		☐	Not Safety Zone C	0

Figure 48: Commodity Category Tab

Vessel call commodity transfers are defined as quantities, expected to be in units of the given commodity. HarborSym performs the necessary calculations to convert this input into tons for each commodity transfer. HarborSym requires information on tons transferred in order to perform draft adjustments, which rely on the tons per inch immersion factor. In addition, information on tons per unit and quantities transferred are critical in the proper development of a synthetic vessel call list in the BLT and CLT modules.

Value per unit is an optional field. This information is used in the vessel class statistics generated as simulation output. Value per unit is not currently utilized in transportation cost calculations.

For users wishing to utilize the Containers, Automobiles, or Passenger units, it is recommended that the analyst contact the Deep Draft Navigation Center of Expertise (DDNPCX) or IWR for guidance and considerations.

6.5.2 Critical Commodities and Safety Zones

Two methods are available for identifying situations in which a vessel carrying a special commodity will receive preferential treatment. The user can classify commodity categories as critical commodities by selecting the checkbox in the Critical Commodity column. Vessels carrying Critical Commodities are tested if the Critical Commodity Rule is in effect. Vessels can also have safety zones. Safety zones are required distances between vessels. If the commodity is a safety zone commodity, the user should select the Safety Zone Type and enter the Safety Zone Distance for this commodity. Additional information on Safety Zones is available in Section 3.2.12 and Section 6.10.

6.6 Port Traffic

The vessel call list is the list of port traffic. The list contains extensive data about the vessels calling and the commodities transferred at the harbor. The A-DAPP and W-DAPP were developed to assist users in developing the port traffic spreadsheet required for a HarborSym study. See the respective user’s guides and training materials for details on how to use these tools to develop a historically-based vessel call list. The BLT and CLT were developed to assist the user in creating a vessel call list that represents future conditions. These modules create a VCDB that, when linked to the HarborSym project through the Study Manager, populates the data in this section of the HarborSym navigation pane.

The required data for the vessel call list includes: unique movement number, arrival date, arrival time, vessel name, harbor entry point, harbor exit point, vessel arrival draft, dock name, dock number, dock

order, commodity, commodity number, units of each commodity transferred, commodity movement direction (import or export), vessel type name, vessel type number, vessel capacity, LOA (length overall), vessel beam, vessel draft, vessel TPI Factor, Flag (nationality), and ETTC (estimate of total trip cargo). Optional data in the vessel call list includes the vessel destination (destination port of exiting vessel), NRT (net registered tons), GRT (gross registered tons), DWT (deadweight tons), Route Group Name, Route Group Number, Vessel Class Name, and Vessel Class Number. The user can select NRT, GRT, or DWT to represent the vessel capacity for each vessel type, as appropriate for the specific ship type. ***Note: if using the BLT to develop a future vessel call database, DWT must be selected as capacity.*** When determining the correct "capacity" of the vessel type, consideration must be given to reasonable deductions, such as stores, bunkerage, or empty slots on containerships. Capacity assignments must also be consistent with any applicable transit rules. For example, transit rules can be parameterized based on capacity values. If, in practice, these rules are applied based on vessel NRT, this must be considered when defining the capacity value for individual vessels.

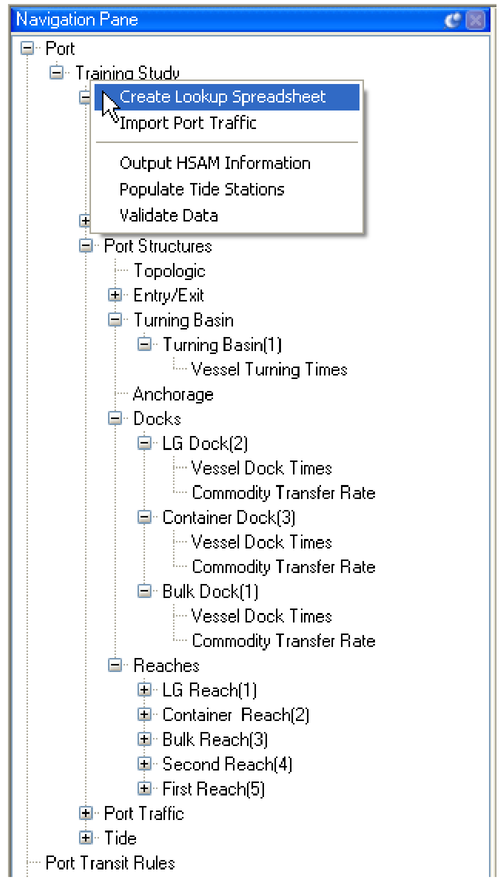


Figure 49: Create Lookup Spreadsheet

The vessel call list can be populated most easily through the Import Port Traffic Template function. This template is a Microsoft *Excel*® workbook with multiple worksheets. Importing the vessel call list will fill four data entry grids under Port Traffic in the Navigation Pane. Alternatively, the user can manually enter all information for the vessel calls through the HarborSym User Interface. Given the amount of data and the necessity to correctly link all elements of individual calls, users are strongly encouraged to utilize the import function. For future simulated port traffic, the BLT and CLT can be used to generate a VCDB. When properly linked to the HarborSym project, the VCDB is viewable through the Port Traffic section under the project name in the navigation pane.

6.6.1 Create Lookup Spreadsheet

To ensure the vessel, dock, and commodity numbers match those assigned within HarborSym, the user can export a template spreadsheet that is in the correct format and has the correct number of columns. To create this template, right click on the project name in the Navigation Pane and select Create Lookup Spreadsheet as shown in Figure 49.

Select the appropriate location for this file by clicking the button (...) beside the Create Spreadsheet File field. After selecting the location of the file, click OK on the Create Lookup Spreadsheet form as shown in Figure 50. A message will appear informing the user that the spreadsheet is ready for data entry. The user should click the OK button, navigate to the specified directory, and then open the spreadsheet using Microsoft *Excel*®.

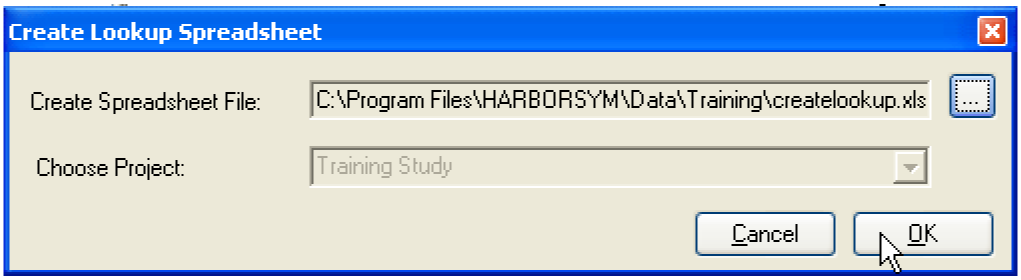


Figure 50: Create Lookup Spreadsheet Dialog Prompt

6.6.2 Populate Lookup Spreadsheet

The template spreadsheet will contain the following tabs:

- Field_Descriptions: contains a definition of all fields included in the "Calls" worksheet.
- Commodity: contains two columns listing the commodity category descriptions entered into HarborSym for the project and the corresponding commodity category number.
- Dock: contains two columns listing the dock descriptions entered into HarborSym and the corresponding dock number.
- Vessel_Types: contains two columns listing the vessel type descriptions entered into HarborSym and the corresponding vessel type number.
- Vessel_Classes: contains three columns listing the vessel class descriptions entered into HarborSym and the corresponding vessel class number and vessel type.
- Route_Groups: contains three columns listing the Route Group name, Route Group Description, and Route Group number entered into HarborSym.
- Flag: contains two columns listing the countries and corresponding codes that can be entered for vessel flag. The value "Z_Foreign" can be used as a default value for non-U.S. flag vessels.
- Calls: contains 30 columns that define the vessel calls, as described below and in Appendix A.

Users can populate the "Calls" tab of the lookup spreadsheet with the vessel call information. Referencing the data populated by HarborSym in the other tabs ensures the spreadsheet will be imported correctly into the model. The DockNumber column should be populated based on the dock worksheet. The CommodityNumber column should be populated based on the information on the commodity worksheet and the VesselTypeNumber should be populated based on the information on the vessels worksheet. Similarly, Vessel Class and Route Group information should be populated

based on the data provided in the corresponding worksheet. The Flag field can be populated based on the information on the flags worksheet. For a large call list, users can utilize the Microsoft Excel® VlookUp function to assist with the entry of these values. For a small call list, users can manually enter these values.

The remaining information should be completed based on port traffic. Users should view the vessel call list as documentation of all vessels arriving at the harbor entrance point(s) during the desired period. All unique vessel arrivals must be assigned a unique Movement Number. This field is used to track vessel calls with multiple row entries in the spreadsheet. For example, a vessel arriving at the entrance point planning to visit two docks within the study system will have two row entries in the import spreadsheet, one for each dock visit, both with the same movement number. The "Dock_Order" field indicates the order in which the vessel will visit each of the docks. Likewise, if a vessel is calling only one dock but exchanging multiple commodities (or importing and exporting commodities), the user must enter multiple rows into the spreadsheet for each commodity exchange (the order of rows is immaterial). These multiple rows must be tagged with the common movement number. Appendix A contains a table defining the column headings and required data entry values for the vessel call list import.

When using the port traffic template, the user must specify ETTC for each vessel call. ETTC is used by the HarborSym kernel to allocate all or a fraction of the at-sea costs for a given vessel call to the subject port. Care must be taken that ETTC is entered accurately for hand-crafted vessel call lists imported into HarborSym. See Section 3.3.1 for details on how ETTC is defined and used.

After the spreadsheet is completed and has all call information entered the user should save and close the spreadsheet.

6.6.3 Import Completed Vessel Call Spreadsheet

The HarborSym import routine dissects the Microsoft *Excel*® workbook and populates the extracted data in the correct location within the HarborSym VCDB. Beneficial features of this capability include the identification of unique vessels within a call list and the assignment of unique vessels to vessel classes (if vessel class is blank). Unique vessels are determined based on the external identifier, vessel name, and physical characteristics including LOA, beam, capacity, and draft. The external identifiers, such as Lloyd's numbers, should represent a unique vessel calling the port. During the import process,

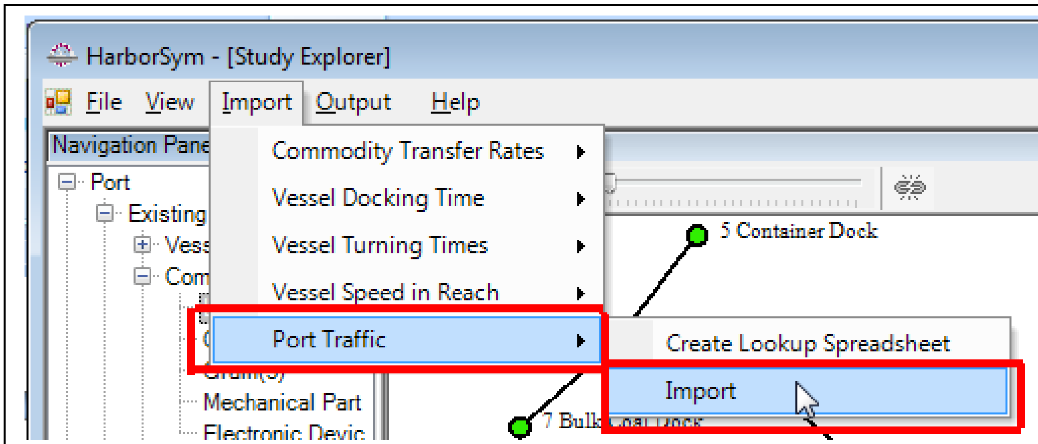


Figure 51: Import Port Traffic

HarborSym allows only one combination of external identifier – vessel name – physical characteristics in a call list. Vessel calls showing identical external identifiers and non-identical vessel names and/or physical characteristics will not be imported into HarborSym. (It is, however, possible to have multiple vessels in the call list with non-unique external identifiers and identical vessel names). All vessel calls unsuccessfully imported into HarborSym are documented. If necessary, users can modify the call list to reflect unique vessels and re-import the data.

Each unique vessel imported into HarborSym is assigned to a vessel class based on the vessel type and physical characteristics if the vessel class is blank. In some instances, the user may know the vessel class and may want to specify this in the vessel call worksheet in the template (e.g., when designation of Panamax, SubPanamax, etc. is known). For the vessels where the vessel class is unknown, the user establishes the vessel class thresholds based on any combination of length, beam, capacity, or draft. During the HarborSym import, vessels with overlapping classifications are assigned to the default vessel class for the corresponding vessel type.

The vessel call list spreadsheet is imported into HarborSym by selecting Import Port Traffic from the Import menu in the Task Bar as shown in Figure 51. This can also be achieved by right-clicking the project name and selecting Import Port Traffic. Click on the button (...) and browse and find the completed vessel call spreadsheet and then ensure that the proper worksheet is selected in the Select Worksheet field. Create Import Log is selected by default and it is recommended that this option be selected. The Create Import Log will create a log of the import and notify the user of any rows that were not imported due to erroneous data, such as non-unique vessel information.

Click the Next button to continue with the import. The user must now select a default vessel class for each vessel type. Ensure that a default class is selected for all vessel types. The default class can be changed by changing the value in the Vessel Type Field as shown in Figure 52.

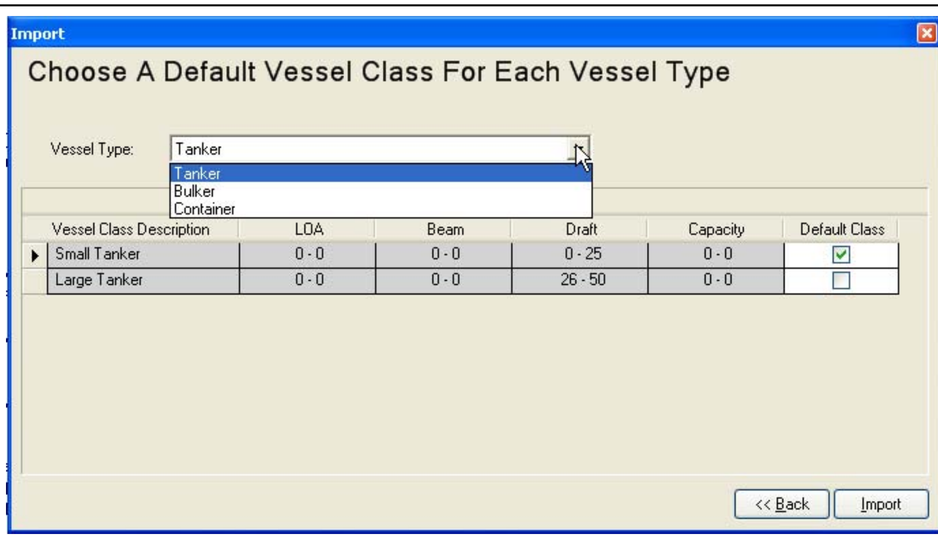


Figure 52: Selection of Default Vessel Class

The default for each vessel type is signified by a check in the row for the Default Class value. HarborSym will use the default class to make vessel class assignments when vessels cannot be assigned to a specific class based upon its measurements. After the default vessel class has been

selected for each vessel type click the Import button. When the import is complete the user will receive a message asking whether to assign Route Groups to blanks or to all vessel calls. After making the selection, a message will appear to indicate that the import has completed. If vessel class Route Group percentages are inconsistent with the Route Groups in the vessel call spreadsheet, an error message will appear indicating which vessel classes need review. If this occurs, the import will function but Route Groups that were blank upon import will remain blank.

6.6.4 Import Error Log

HarborSym creates an Import Error Log that should be checked to ensure all vessel call data has been imported successfully. This file is in the same location as the vessel call import spreadsheet. Locate this file using Windows® Explorer and open it using Notepad (or other text editor program). The error log documents default vessel class information, the assignment of each unique vessel to a vessel class to and lists the total number of vessel calls, dock visits and commodity transfers. Any records that were not imported due to data errors will be listed in the last section of this document. A sample import error log is available in Appendix A.

If there are numerous import errors recorded in the log, the Microsoft *Excel®* file should be revised and re-imported. When using this approach, all vessel call information in HarborSym is automatically deleted before the new spreadsheet is imported.

6.6.5 Port Traffic Data Entry Grids

After the vessel call list is imported, the four port traffic data entry grids in the HarborSym Study Explorer should be reviewed. These include: Unique Vessels, Vessel Calls, Dock Visits, and Commodity Transfers. Each of the columns in these grids contains a sort function that allows the user to review data more easily. For example, the highest and lowest beam of vessels can easily be reviewed by clicking on the arrow immediately to the right of the beam column heading. Vessel calls can be rendered inactive during a simulation by removing the check in the active column.

Unique Vessels

This grid is populated with all the unique vessels calling the study harbor. A unique vessel may call at the port multiple times but will only be listed once in the Unique Vessels tab. If the Port Traffic is populated using the import routine, then the unique vessels are determined from the imported spreadsheet based upon the external identifier field, the vessel name, and physical characteristics

Vessel Calls

This grid provides information on the calls made by each unique vessel. The fields included in this grid are:

- Vessel Call ID: This field is an automatically generated identifier unique for each vessel call. The user cannot edit this field
- Iteration Number: In the current version of HarborSym the value in this field should be one (1) for all entries. When using the HarborSym import feature, the appropriate value will be populated automatically.
- Movement Number: This number is populated during the import routine and will match the user defined movement number field in the import spreadsheet.

- Vessel Name: This field must correspond with the name of a vessel in the Unique Vessels table. Users can edit this field through the pull down menu.
- Arrival Date: The value entered in the arrival date field represents the date (MM/DD/YY) and time the vessel arrives at the system entry point. Users can edit this field through the pull down calendar.
- Entrance / Exit Point: This field must correspond with a node identified as an entrance or exit point. Users can edit this field through the pull down menu.
- Active: By activating this checkbox, users instruct HarborSym to simulate the call during all scenarios for the project. If the checkbox is not selected, HarborSym will not include the vessel call in simulations.
- Entry Draft: The value in this field is the vessel draft upon arrival to the system, expressed in feet.
- Route Group: This is the route specified or assigned to the specific vessel call and must correspond with a route group entered in the “Vessel Info” portion of the navigation tree.
- ETTC – Estimate of total trip cargo, estimated in the CLT as cargo on board the vessel at arrival plus cargo on board the vessel at departure, in tons. This field is used by HarborSym to allocate all or a portion of the at-sea costs to the subject port. See Section 3.3.1 for details.

Dock Visits

The Dock Visits tab provides information on all dock visits made during each vessel call. The dock visit is linked to the vessel information through the “Vessel Call ID” field. The order field indicates the sequence in which a vessel will visit multiple docks in a single vessel call.

Commodity Transfers

This data entry grid contains information on the quantity of cargo moved at each dock during the dock visits. A separate entry must be made for each commodity category exchanged at each dock. The quantity, in units, must be provided for both import and export movements.

6.7 Dock/Turning Basin Matrix

For each vessel class – dock combination, the user must assign a turning basin that the vessels will use

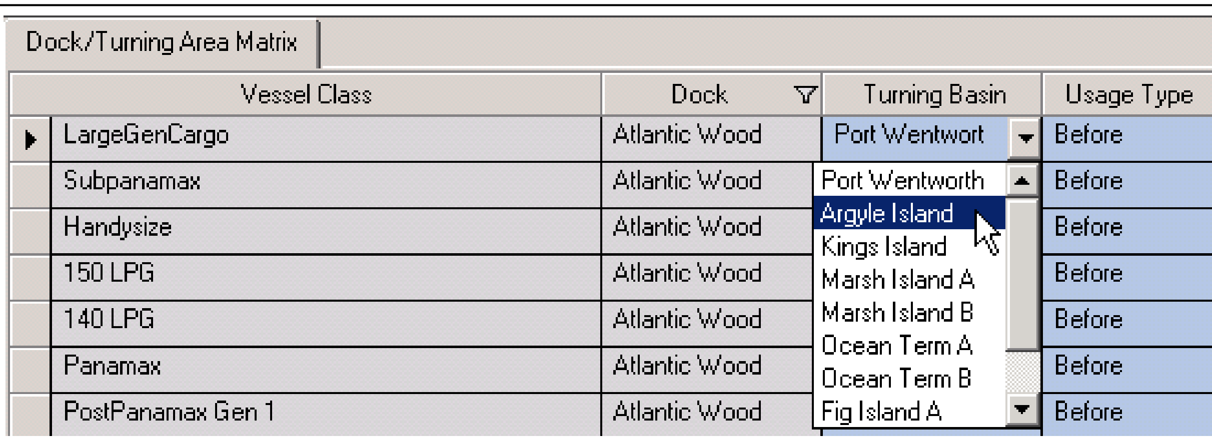


Figure 53: Dock/Turning Basin Matrix

for turning maneuvers, and indicate if the vessels will turn before, after, heaviest, lightest, or not at all. This assignment is done through the "Dock Turning Basin Matrix", located within the "Port Traffic" branch of the navigation pane. This is depicted in Figure 53. The matrix can only be populated after vessel classes, docks, and turning basins have been entered. Once information on these port structures is entered, the Dock Turning Basin Matrix will automatically populate the vessel class and dock combinations. The user can select the appropriate turning basin and usage type from pull down menus.

6.8 Tide and Current

Tide has a significant impact on harbor vessel traffic, because of depth constraints and vessel traffic rules. Tide should be introduced to the model if the draft of any calling vessel approximates the channel depths in the harbor. Current is introduced to the model only if a vessel traffic rule requires consideration of current.

6.8.1 Tidal Stations

Tidal stations are locations at which tides are measured. Standard tidal stations are available in HarborSym and the appropriate local stations should be selected for use in a study. To populate the tidal stations, right-click on the project name and select Populate Tide Stations, as shown in Figure 54. The latitude and longitude of the harbor and a search radius must be entered to obtain a list of the relevant tidal stations. Once this data has been entered click the Retrieve button. The appropriate tidal stations need to be enabled by checking the enable box. Select "Tide" from the menu for station type. Click the Save button to save these changes. The Populate Tide Stations window is shown in Figure 55.

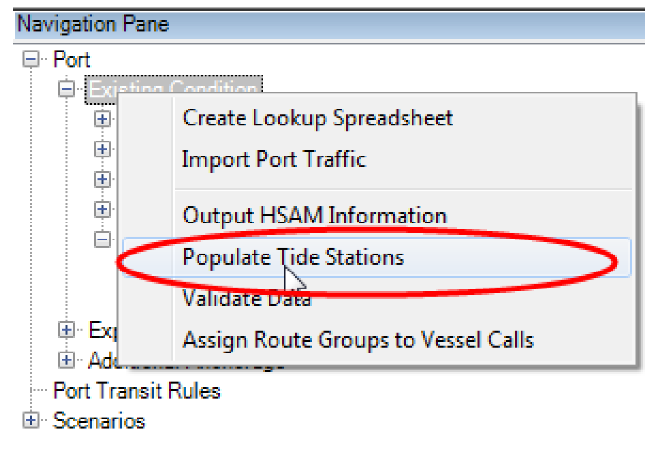


Figure 54: Populate Tide Stations

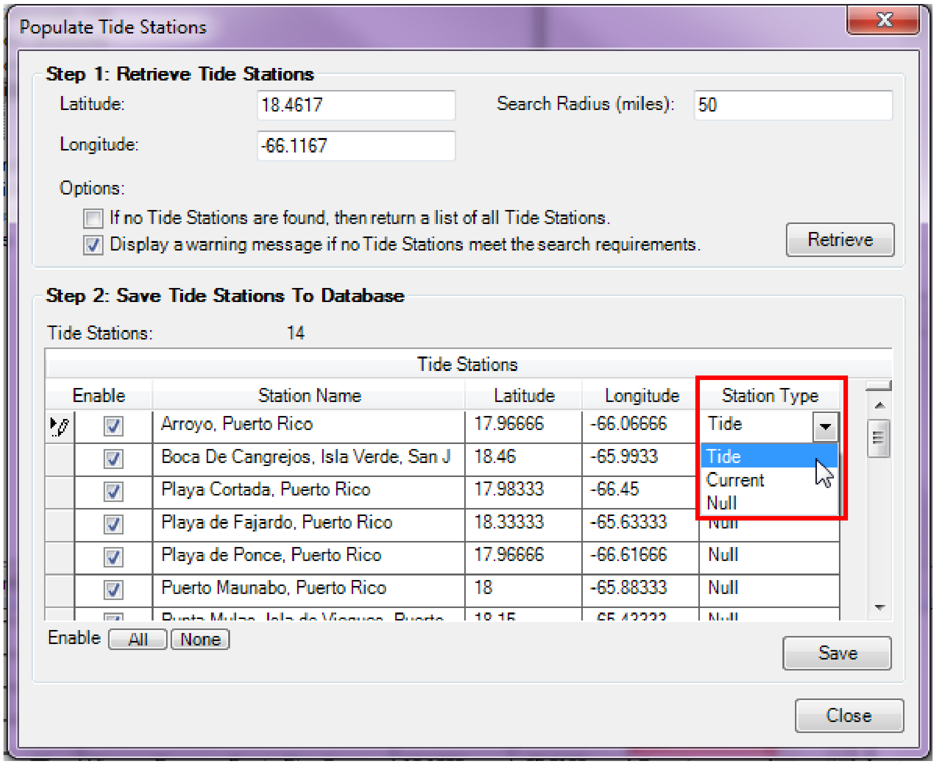


Figure 55: Populate Tide Stations Window

Once tide stations in the study area have been identified, the user should assign the appropriate tide stations to each reach through the "Tidal Stations" branch under "Tide" in the Navigation Pane. The data entry grid will automatically populate with the available reach name. For each reach the user can select two nearby tide stations from which HarborSym will pull necessary tidal information. The tide stations identified in the "Populate Tide Stations" step will appear as options in the pull down menus. The interpolation field should be a value between 0 and 1, where an entry of 0 pulls tide value entirely from Tide Station 1 and an entry of 1 pulls tide value entirely from Tide Station 2. For example, if a reach is closer to Tide Station 1 than Tide Station 2, a value of 0.25 might be entered.

To view the complete list of tide stations selected during the "Populate Tide Stations" step select the main "Tide" branch from the navigation tree. This screen is blank until tide stations are populated in the pop-out window.

6.8.2 Current Stations

Current stations are stations from which the flow of current is measured. All current stations are available in the HarborSym model. To enable current stations follow the same process as tidal stations except select "current" as the station type in the "Populate Tide Stations" window. Current stations are assigned to reaches by clicking on "Current Stations" in the Navigation Pane. The user should click the plus icon beside Tide in the Navigation Pane so that Current Stations will appear. Clicking on Current Stations in the Navigation Pane will prompt the Current Stations Data Entry Grid to appear. Only the reaches with vessel traffic rules considering current will appear in the data entry grid. A current station must be selected for each reach where a vessel traffic rule uses current.

6.9 Vessel Speeds and Times

To simulate vessels transiting the harbor and transferring cargo, the sailing speed and the amount of time spent at the docks is simulated. A range of sailing speeds and times (e.g. docking time or turning time) must be entered into HarborSym. Speeds are entered for each vessel class / reach combination for light and loaded vessel status in knots. Triangular distributions for each vessel class are required for the various time categories. Section 6.2.6 provides detail on entering speeds and reaches through the data entry grids. Alternatively, users can populate these fields by importing a Microsoft *Excel*® spreadsheet. Appendix A describes how to use templates for data entry of speeds and times.

6.10 Safety Zones

A safety zone is a particular transit rule that functions similarly to placing a protective bubble around a vessel as it moves. The distance extends from the ship's bow and the ship's stern. The safety distance, designated by the user, is equal for both sides. No moving vessels are allowed next to the designated safety vessel. Safety zones are user-defined, commodity-specific characteristics. These characteristics describe how the model should treat vessels carrying these commodities.

The three choices (not safety zone commodity, always safety zone commodity, and safety zone commodity when carrying) define the application of safety zone rules for each commodity. When selected, "Always Safety Zone Commodity" will require the safety zone distance to be followed regardless of the quantity of commodity carried on the vessel. Under the "Safety Zone Commodity When Carrying" option, HarborSym will only apply the safety zone when the selected commodity is present on the vessel. Regardless of the option selected, safety zones are only applied in reaches with active safety zone rules.

For example, consider a situation where a vessel imports liquefied gas into a hypothetical harbor, completely discharges its cargo at the dock, and departs the port without any cargo. In this scenario, the "Maintain Safety Zone" transit rule has been activated at the port level and thus applies in all reaches. If liquefied gas has been designated a safety zone commodity under the "Always Safety Zone Commodity" option, the safety zone will be applied to both the inbound and outbound transits because the vessel carried the commodity during the current vessel call. If the "Safety Zone Commodity When Carrying" option was selected, the safety zone would apply to all reaches on the vessel's inbound transit only. If the "Not Safety Zone Commodity" option was selected, safety zones would not apply to liquefied gas, regardless of the activated port level transit rule.

6.10.1 Activate Safety Zones

There are two main processes to activate safety zones in HarborSym. First, the user must designate commodities for safety zone and enter the associated specific details. Then, the "Maintain Safety Zone" rule must be designated for all reaches, or for specific reaches.

6.10.2 Designate Safety Zone Commodities

The application of safety zones is triggered by the commodities carried by a vessel, rather than the vessel type or class. Designating safety zone commodities is done through

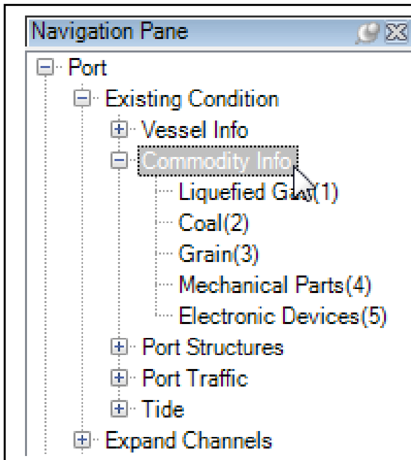


Figure 56: Commodity Information

the Commodity Category tab within the Commodity Info branch of the Navigation Pane, as shown in Figure 56.

In the Commodity Category tab, shown in Figure 57, the "Safety Zone Type" field is populated using a pull down menu. For commodities designated as either "Always Safety Zone Commodity" or "Safety Zone Commodity When Carrying", a safety zone distance must also be entered, measured in feet. This is the additional buffer that will be included on both the bow and stern of the vessel in reaches with active safety zone rules.

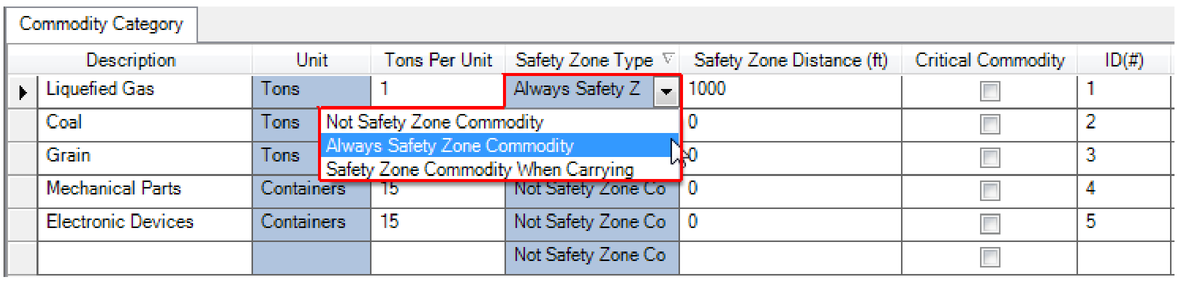


Figure 57: Selecting Safety Zone Commodity

6.10.3 Activate Safety Zone Rules for Reaches

A port-level transit rule can be applied if safety zones must be observed universally throughout all reaches within the network. If defined and activated, the Maintain Safety Zone rule will be enforced in all reaches for all safety zone commodities. This provides efficiencies over manually entering the rule in all reaches. Note, however, that if multiple projects have been created within one study (e.g., existing condition, future with-project conditions), all projects will be impacted by the port-level rule.

A port-level transit can be entered by selecting the "Port Transit Rule" branch in the Navigation Pane, shown in Figure 58. Select the Maintain Safety Zone rule in the Rule Type pull-down list. The applicable condition under which the safety zone rule will apply can be defined as "Always", "Day", or "Night" based on port rules, shown in Figure 59. The latitude and longitude entered into the "Study Manager" will determine daylight and night hours. Specific hours cannot be designated.

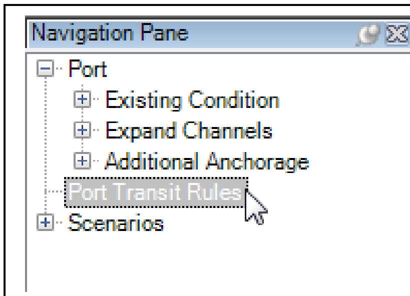


Figure 58: Port Transit Rules Selection

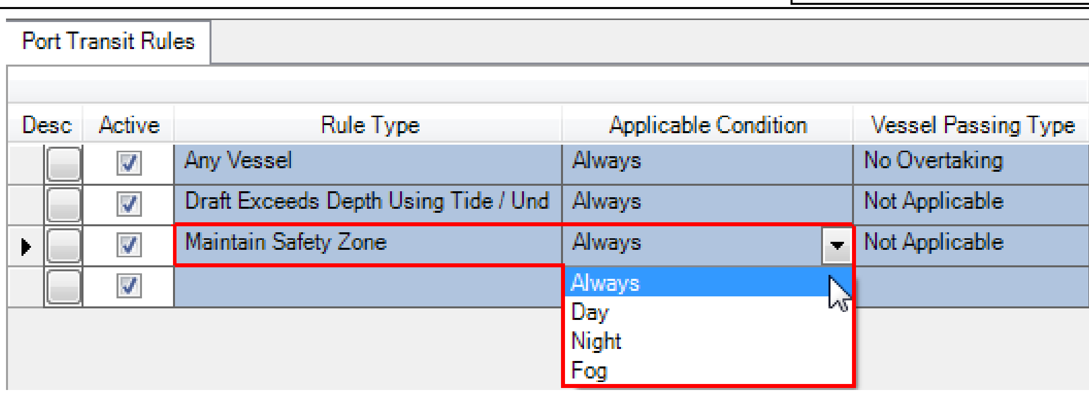
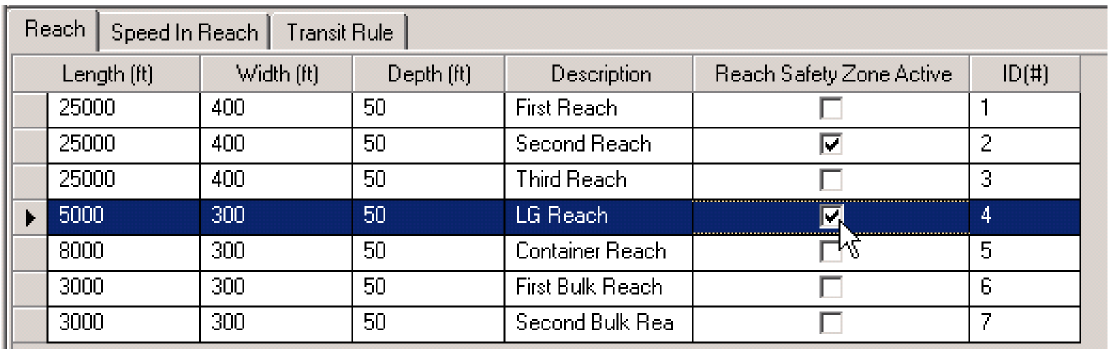


Figure 59: Selecting Port Transit Rule Conditions

Vessel passing type (overtaking or passing) is not applicable for this rule and should be designated as such. The "Active" box must have a check mark in order to activate the rule.

If safety zones are applied only to select reaches within the harbor, the rule must be entered into each applicable reach individually. To define and activate safe zones in specific reaches, navigate to the Reach data entry grid under "Port Structures". Click on the "Reach Safety Zone Active" box for all reaches where the safety zones must be observed, as shown in Figure 60 As with port-level safety zone rules, vessel passing type (overtaking or passing) is not applicable for this rule and should be designated as such. The "Active" box must have a check mark in order to activate the rule.



Length (ft)	Width (ft)	Depth (ft)	Description	Reach Safety Zone Active	ID(#)
25000	400	50	First Reach	☐	1
25000	400	50	Second Reach	☑	2
25000	400	50	Third Reach	☐	3
5000	300	50	LG Reach	☑	4
8000	300	50	Container Reach	☐	5
3000	300	50	First Bulk Reach	☐	6
3000	300	50	Second Bulk Rea	☐	7

Figure 60: Activating Reach Safety Zones

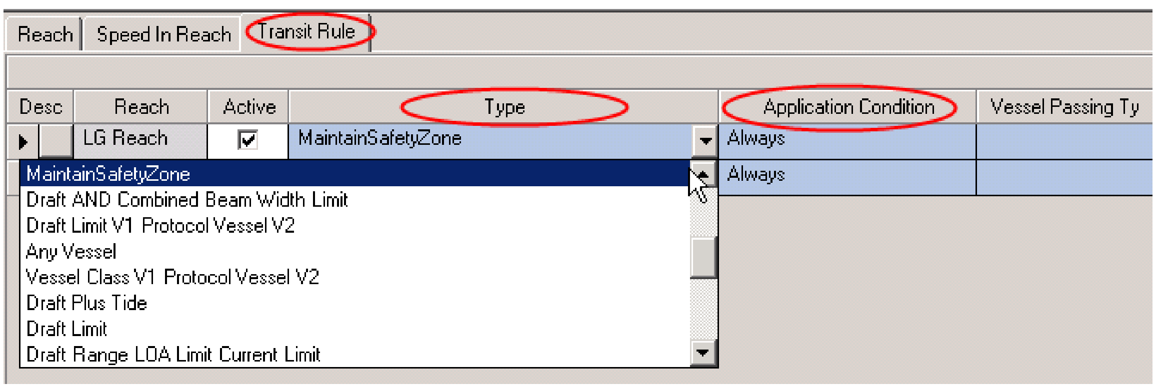


Figure 61: Reach Transit Rule Selection

The "Maintain Safety Zone" rule must be parameterized for each reach with a check mark in the "Reach Safety Zone Active" field. To do so, highlight the reach as shown in Figure 60 and navigate to the Transit Rule tab. The "Maintain Safety Zone" rule should be selected with the correct applicable conditions (always, day, or night), as displayed in Figure 61.

6.11 Data Validator

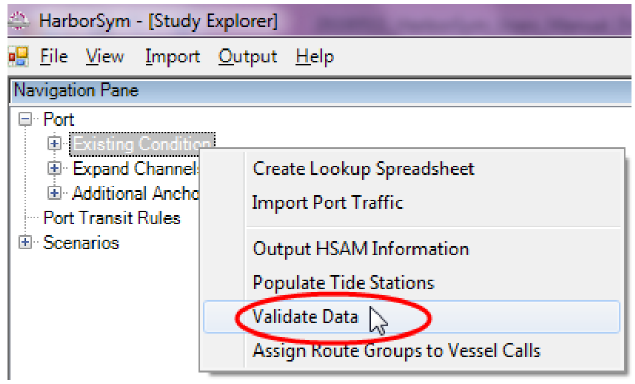


Figure 62: Data Validation Tool

As HarborSym requires a great deal of consistent user defined information to function properly, a data validation tool has been developed to aid the user in determining the completeness and reasonableness of the information entered. Users can access the data validation tool by right clicking on the project name and selecting Validate Data, as shown in Figure 62. This will launch the Data Validation Form, within which the user can determine which data fields should be verified, to include: Port Information, Vessel Information, Port Structures, Port Traffic, and Tide Information. After checking the desired data elements for validation, the user should select "Check Data". HarborSym then generates a report outlining the status of the user-provided data. The report will state Error or Warning and list the problem in any categories for which data needs attention. This report can be printed or saved. A sample data validation report is included in Appendix A.

The Data Validator will list any data entry fields that are empty, but these empty data entry fields will not necessarily cause a problem. As an example, the Data Validator will note any vessel class without speeds entered in a reach. However, not all vessel classes transit every reach. Not having a speed entered for passenger vessels on a reach used only to access a container dock may not cause a problem. Having the automated Data Validator function list all missing data fields allows the user to systematically check for problems.

The Data Validator tool compares the user provided data against established ranges of values, as set by the user, that are acceptable for input. Input values outside of the defined range generate an error message during data validation. The configuration settings can be set up selecting "Configuration Settings" under the "File" menu option. Figure 63 captures the configuration settings window.

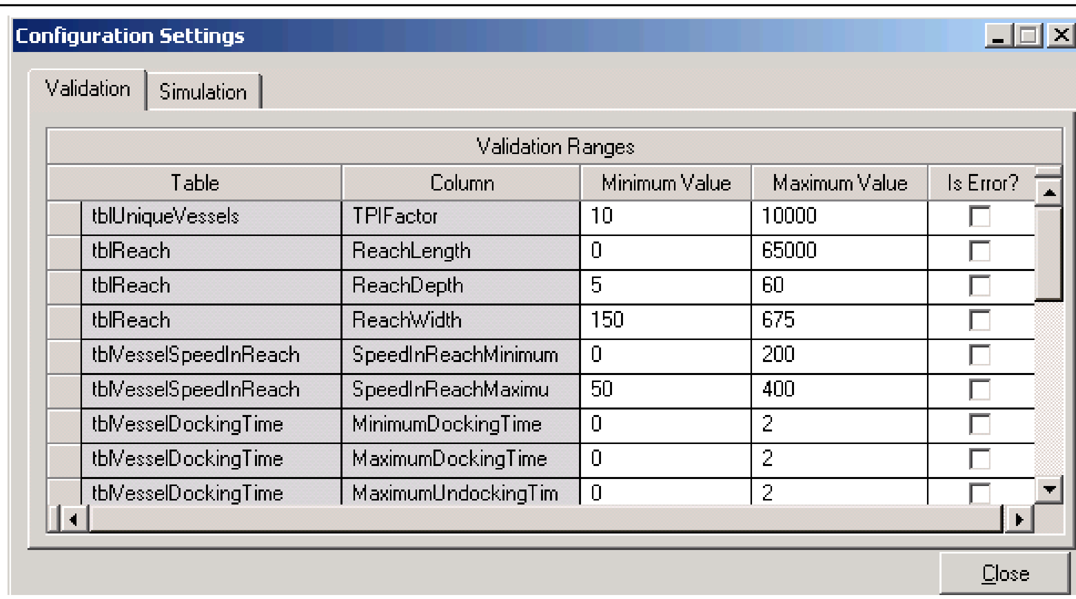


Figure 63: Data Validation in Configuration Settings

The data validation settings available under the "Validation" tab of the Configuration Settings window include fields covering physical dimensions of the reaches (length, width, depth), vessel speeds, and docking times, as defined in Table 4. For these fields, the user must provide minimum and maximum values that represent a reasonable range within which data values can fall. The user should check the "Error" box for all data fields that represent absolute maximum/minimum values. The data validation report will highlight data values that fall beyond the established thresholds, noting in particular those values identified as errors.

Table 4: Validation Settings

FIELD	DESCRIPTION	VALUE
TPI Factor	Check of tons per inch immersion (TPI) factor, used primarily in draft adjustment calculations after cargo exchanges (see Section 3.3.2).	Enter a single minimum and maximum value against which all vessel classes will be checked, expressed in inches.
Reach Length	Check of reach length to identify data entry errors in network design. All reaches in the network are compared against this field.	Enter values in feet.
Reach Depth	Check of reach depth to identify data entry errors in network design. All reaches in the network are compared against this field.	Enter values in feet.
Reach Width	Check of reach width to identify data entry errors in network design. All reaches in the network are compared against this field.	Enter values in feet.
Speed In Reach Minimum	Check of minimum speed in reach. All reaches in the network are compared against this field.	Enter values in knots.
Speed In Reach Maximum	Check of maximum speed in reach. All reaches in the network are compared against this field.	Enter values in knots.
Minimum Docking Time	Check of minimum time vessels will spend docking. All docks and vessel classes are compared against this field.	Enter values in hours.
Maximum Docking Time	Check of maximum time vessels will spend docking. All docks and vessel classes are compared against this field.	Enter values in hours.
Maximum Undocking Time	Check of maximum time vessels will spend undocking. All docks and vessel classes are compared against this field.	Enter values in hours.
Minimum Undocking Time	Check of minimum time vessels will spend undocking. All docks and vessel classes are compared against this field.	Enter values in hours.
Min Vessel Turning Time	Check of minimum time vessels will spend in turning maneuvers. All turning basins in the network are compared against this field.	Enter values in hours.
Max Vessel Turning Time	Check of maximum time vessels will spend in turning maneuvers. All turning basins in the network are compared against this field.	Enter values in hours.

6.12 Simulations

A simulation provides estimates of vessel transit times and operating costs based upon the project and the run parameters. The run parameters are defined by the scenario, which specifies the timing and duration of the simulation. Simulations consist of one or more iterations, as defined by the user.

6.12.1 Scenarios

A scenario is a definition of the run parameters of a simulation. Scenarios define the period of vessel traffic simulated and how the simulation is conducted. Scenarios are stored by name, which appears in the Navigation Pane under "Scenarios. To set up a scenario, click on this field in the Navigation Pane, as shown in Figure 64. The Scenario Definition Data Entry Grid, shown in Figure 65, will display all the options, called "run parameters", that the user must specify for a specific scenario.

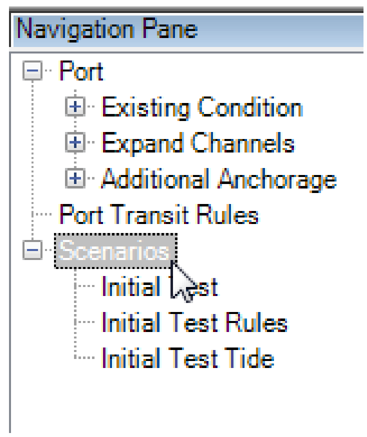


Figure 64: Scenarios

Although the scenario information is displayed in the Scenarios data entry grid, it is also possible to enter the information in the scenario editor form. After creating a scenario in the data entry grid, select the new scenario in the navigation pane under Scenarios. This will launch the Scenario Editor form, shown in Figure 66. Definitions and further information concerning the different options available can be found in Sections 3.2.15 and 8.2.1.

Scenarios

Name	Description	Start Date	Iterations	Duration	Step Time	Step?	Arrival Wait Increment	Dock Departure Wait Increment
Initial Test	240 hours starting	02/20/10 00:00:0	25	240	1	☑	0.25	0.25
Initial Test Rules	240 hours with rul	02/20/10 00:00:0	25	240	1	☐	0.25	0.25
Initial Test Tide	240 with tide and r	02/20/10 00:00:0	25	240	1	☐	0.25	0.25
		05/18/10 00:00:0	1	0	1	☑	0.166667	0.166667

Figure 65: Scenario Paramters Data Entry Grid

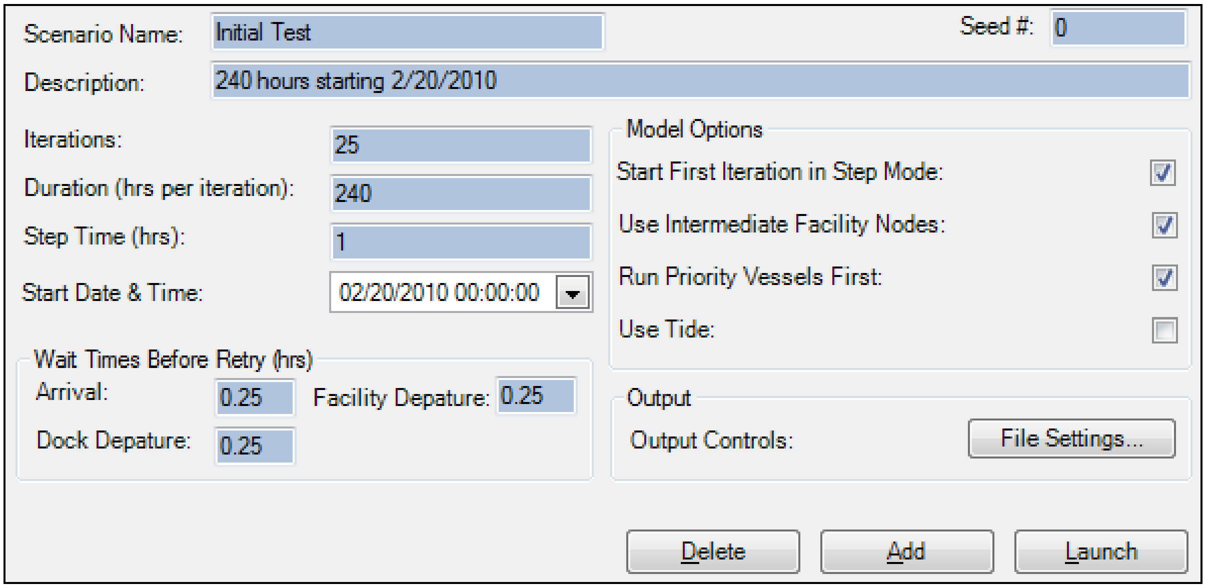


Figure 66: Scenario Editor

6.12.2 Launch a Simulation

After the scenario has been defined, the simulation can be launched by clicking on the Launch Button at the bottom of the Data Entry Pane. If the study contains multiple projects, the user must select the projects to be simulated and click Launch in the new dialog box. If the "Start First Iteration in Step Mode" option was not selected, the simulation will proceed until completion of all iterations and visualization will not be available.

If the user has chosen to start the simulation in the step mode, the user should click OK on the message received concerning starting the simulation in step mode. Clicking on the Step Button in the Visualization Screen will begin the simulation. Clicking on the Next Button will process the next in the simulation. Selecting the Continuous Button will process events continuously at a steady speed with animation, or the resume button to process without animation (which runs significantly more rapidly). When the simulation is complete the user will see a dialog box with average times and delays displayed. Clicking the OK Button will close the simulation. Additional information on controlling the within-simulation animation is contained in Section 8.3.

6.12.3 Cancel a Simulation

A simulation can be cancelled while in process. Simulations with multiple iterations may take several hours to complete and the user may want to correct data entry based upon the visualization screen. To cancel a simulation, the user should click on Halt. A dialog box will appear with the option to cancel the simulation. If multiple projects were selected for simulation, each will have to be canceled individually.

6.13 Cloning

HarborSym Study manager contains a cloning feature that allows the user to create a new project within a study that contains all of the data entered for the original project. The user can then modify the values that would change if the harbor improvement was implemented as the alternative project. To clone a project the user should move to the Study Manager by selecting Study Manager from the File menu.

The user should now click the Clone Project button on the Study Manager Dialog Box, shown in Figure 67 and enter a name and storage location for this new project. After specifying the name and location of the new project, click the OK button. Click the Close Button to close the Study Manager and select Study Explorer from the View Menu. The new project will appear in the Navigation Pane under Port below the original project.

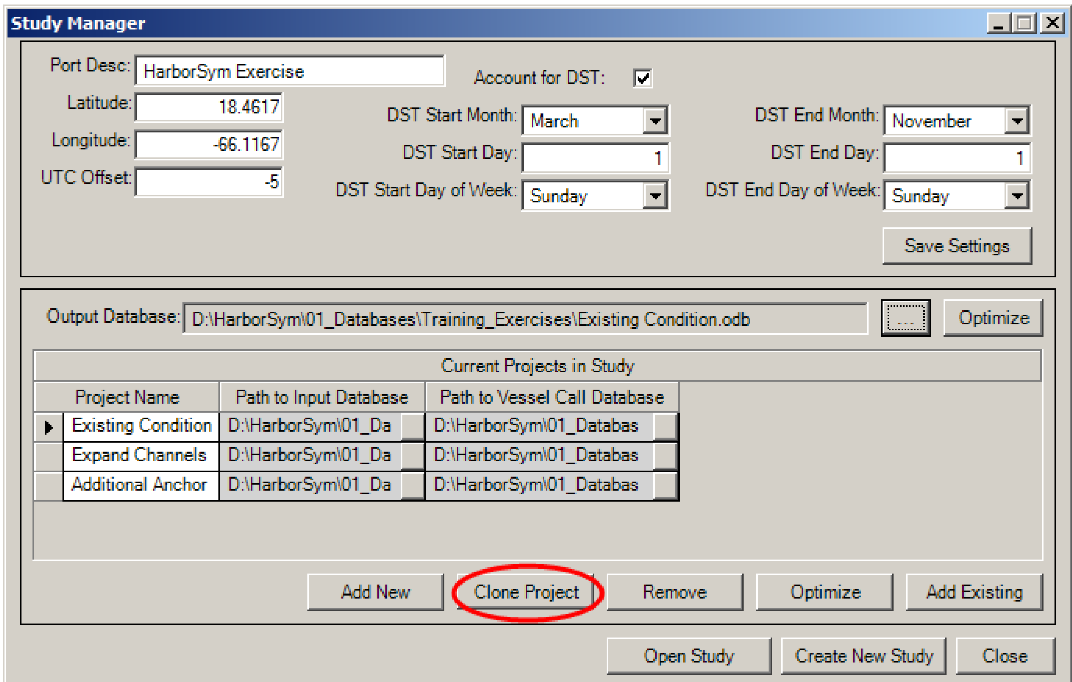


Figure 67: Clone Project in Study Manager

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Section 7

Generating a Synthetic Call List Using Loading Modules

HarborSym does an analysis of an individual vessel call list, developing detailed cost data for the situation presented in the data. Typically, the existing condition will be based on historical vessel call data, but projections must be developed for future and with-project situations. Separate HarborSym runs are made for the without- and with-project conditions, for existing conditions and projected futures for the desired planning horizon.

A complication in using HarborSym for USACE planning studies is thus the generation of vessel call lists that represent fleet arrivals and loadings under future without- and with-project conditions. That is, a with-project vessel call list must represent the future fleet and commodity demands for import and export at the port and the associated commodity transfers and vessel loadings must be reflective of the possibilities offered by the deepened channels.

Given the distinct nature of non-containerized and containerized ships, separate tools were developed to address their specific vessel loading behavior. The Bulk Loading Tool (BLT) module generates a synthetic future vessel call list based on user provided information on the fleet and commodity demands for all non-containership vessels, such as breakbulk, bulk carriers, barges, cruise ships, and tanker vessels. The Container Loading Tool (CLT) module produces a containership-only synthetic future vessel call list based on user inputs describing commodity forecasts at docks and the available fleet. Given the nature of the HarborSym database structure, the BLT and CLT-generated vessel call lists must be combined into a single vessel call list for cases where both types of traffic are to be modeled. The Combiner module was developed to address this need. The following sections describe the steps to create the synthetic vessel call database using these modules.

While the general function of the CLT is similar to the BLT, there are many differences amongst the tools which should be considered and fully understood. For example, the specific vessel loading behavior of containerized vessels is different from generalized bulk vessels and thus the vessel loading routine in the tools is different. The BLT generates synthetic vessels using statistical routines while the CLT generates vessels by selecting from standard vessel definitions in a sub-class. The CLT allows for seasonal patterns in shipping throughout the year while the BLT does not. Differences exist amongst the user interfaces as well. The BLT is tree structured while the CLT is menu driven. The user is able to populate much of the BLT data requirements using a statistical routine while the user of the CLT must manually enter much of the required data. Data edited in the BLT tables must be saved before closing the table while edits to the CLT viewable tables are automatically saved. These differences should be understood when using both the CLT and BLT to generate a vessel call database.

7.1 Create Synthetic Bulk Call List Using Bulk Loading Tool

The BLT was developed to assist users in generating a synthetic future vessel call list for non-containership vessels. The BLT is launched from the HarborSym Tools menu, as shown in Figure 68. Details of the theory, design, data inputs, and user interface of the BLT can be found in Section 4.1. The following sections outline the steps to create a synthetic call list for generalized bulk vessel traffic

using the BLT. The end result of the process will be a fully populated VCDB that can be used directly by HarborSym. The BLT-generated VCDB must be combined with the CLT-generated VCDB using the Combiner module if containerized traffic is modeled in the analysis.

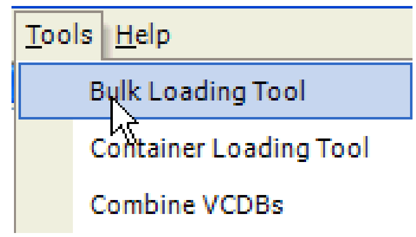


Figure 68: Launch Bulk Loading Tool

7.1.1 Set Working Files

The BLT has been designed to reduce the amount of data input required by the user. Rather than reassert the basic parameters of the study, such as docks, vessel types, commodities, and route groups, the user can direct the BLT to the HarborSym IDB that already contains this information. Note that the IDB should reflect the future conditions, including any commodity categories forecasted to be exchanged, route group parameters, and/or vessel classes anticipated. For example, if a new vessel class is forecasted to call the port that did not call historically (such as larger bulk vessels), then this vessel class must be initially setup in the project through the HarborSym UI. Note that all data elements must be complete for the new commodity, route group, or vessel class. Be certain that the 'Default TPI' field in the Vessel Class Attributes tab is complete as this value will be utilized to generate synthetic vessel characteristics.

Additionally, the BLT can be directed to a historical VCDB that contains pertinent vessel class information that is used to create the synthetic vessels for the future call list (for vessel classes historically call the port only, new vessel class information will draw from the IDB to generate synthetic vessels). This feature of the module not only saves the user time by eliminating the need for duplicate data entry, but it also ensures the accuracy of the data and its consistency with a HarborSym IDB.

The user must link the BLT module to the appropriate IDB, VCDB, and FCDB databases (databases are explained in Table 1: Databases Used In Analysis on page 6). To begin, select "1. Set Working Files" from the Navigation Pane, as shown in Figure 69. When this is selected, a form will appear in the Options Pane that assists the user in specifying the databases. The Data Pane will be blank during this step. Note that until all the databases have been specified, no other option is available to the user in the Navigation Pane.

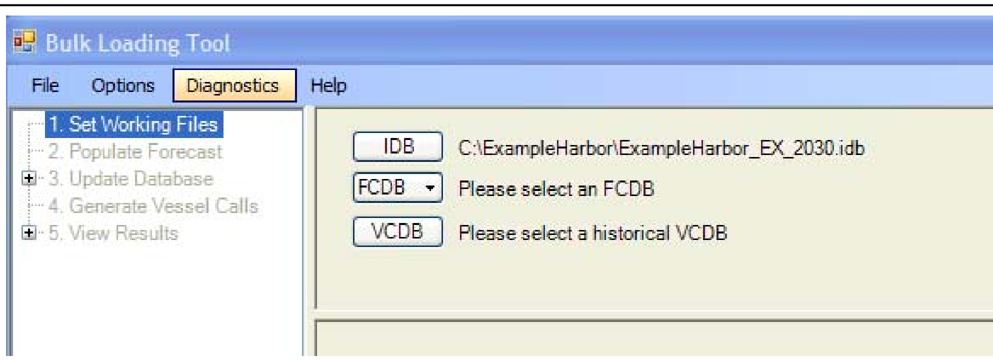


Figure 69: Attach Appropriate Databases to BLT

The IDB, or input database, describes project layout, including the docks, vessel types, vessel classes, and commodity categories. It is important to attach the BLT module to the correct input database, as

this database defines the vessel and commodity classifications that provide the basis for a synthetically generated call list. Also, the linked IDB must have all data fields completed, including min and max parameters for vessel characteristics.

The VCDB, or vessel call database, documents the unique vessels that call the port, and all the calls and commodity transfers made by these vessels. Initially, a populated VCDB, possibly housing the existing condition call list, should be attached to the BLT. An existing condition (or other populated vessel call database) is used to populate basic information for the BLT forecast, such as the logical constraints and vessel class statistics.

The final database that must be assigned is the FCDB, or forecast database. This database is unique to the BLT and stores information about commodity forecasts at docks, constraints on vessel class capability to carry commodities and serve individual docks, and the vessel fleet. In addition, the statistical information necessary to generate synthetic vessels is stored in this database. Initially, a blank FCDB should be attached to the BLT. This can be done by selecting "Create from Template" from the pull down menu under FCDB. Follow the prompts to provide a file name and save location for the new FCDB.

After the appropriate IDB, VCDB, and FCDB have been linked to the BLT, the user should save the database configuration, if desired. Saving the configuration will preserve the links if the user should need to close the BLT and re-open to complete an analysis at a later time. To save the database configuration, choose "File/Save Config" from the BLT menu options, as shown in Figure 70.

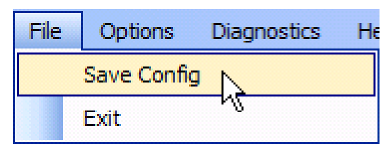


Figure 70: BLT--Save Database Configuration

7.1.2 Populate Forecast

After attaching the BLT to the correct supporting databases, the blank forecast database (FCDB) must be populated. This is accomplished through either manually inputting the information in the tables or by selecting an already populated IDB and VCDB that will be used as the starting point. The information that is needed includes:

- Dock: Constraints describing the docks available. This grid is populated based on the IDB and is not editable by the user to ensure consistency.
- Fleet Specification: for each vessel class, the maximum number of port trips (vessel calls) available for the forecast year and the vessel class allocation priority; the allocation priority determines the order in which vessel classes are called upon to satisfy commodity forecasts (allocation priority of 1 is loaded first).
- Commodity Forecast at Dock: the total amount of each commodity to be imported and exported at each dock.
- Dock Vessel Class: the vessel classes that are able to service each dock; if a vessel class – dock combination is not present in this table, the vessel class will not be able to satisfy any of the commodity forecast at the dock.
- Vessel Class Commodity Category: an identification of the commodity categories that can be loaded on each vessel class, as well as a description of cargo exchange behaviors including:

- A triangular distribution (minimum, most likely, maximum values) for loading the vessels by import and export, describing the percent of the vessel capacity that will be loaded or unloaded at the study port);

- Direction of commodity movements: export only, import only, both import and export, or random (calls of the class can be either import only or export only movements but not both on a given call);

- Import percentage for vessel classes assigned as "random" loading.

- Vessel Class Route Group: the assignment of route group to each vessel class and a percentage of all calls by the class that sail on the route.
- Vessel Class Capacity Regression: a smoothed CDF capacity function for each vessel class.
- Vessel Class Regression: for each vessel class, regression information for deriving length overall (LOA), beam and design draft from capacity.
- Vessel Class TPI Regression: for each vessel class in the historical VCDB, an assignment of the beam, draft, capacity, and LOA coefficient to be used in developing the vessel TPI.

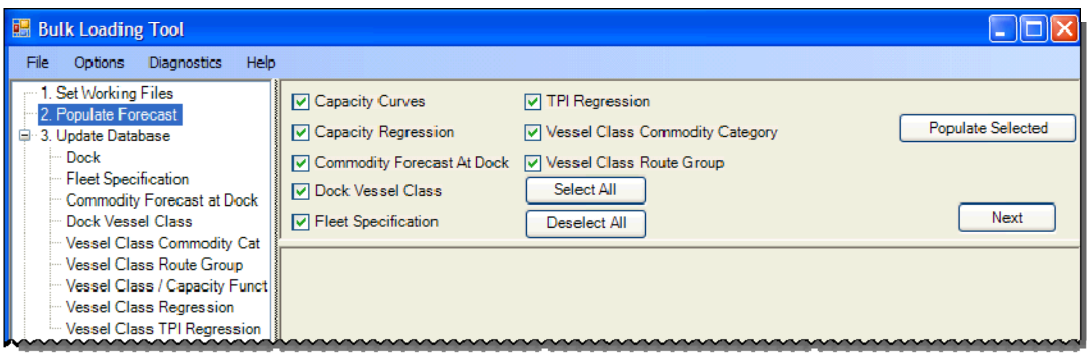


Figure 71: BLT Populate Forecast Options

As these data requirements are extensive, an existing VCDB can be used to populate the forecast database using statistical routines from Extreme Optimization. The user has the option to select which tables should be populated with data from the existing VCDB by deselecting any options they do not want populated, as shown in Figure 71. All selected tables will be filled with data corresponding to the information contained in the attached VCDB. For example, if the "Commodity Forecast at Dock" option is selected, the commodity forecasts at each dock will be populated in the forecast database with the actual commodities transferred at the docks in the existing vessel call list referenced in the "Set Working Files" step. Using an existing VCDB to populate the FCDB is especially useful in generating the logical constraints (e.g., which commodities move through each dock and which vessel classes call each dock) and populating the statistical tables. To complete the FCDB population, the user should select the desired tables to be filled, and then select the 'Populate Selected' button located on the right of the form (shown in Figure 71).

7.1.3 Update Tables in Database

Selecting the tables shown under "Update Database" will display the table data for review after the population routine has been executed. Using an existing VCDB to populate the FCDB reduces the data entry requirements, but does not eliminate the need to review and manually update the tables with appropriate forecast information. All data in the tables must be reviewed and adjusted, as necessary, to reflect the forecasted conditions. To begin, select a table to review under "Step 3: Update Database", as shown in Figure 72. The key information that should be reviewed and/or is editable within the FCDB will display in the data pane (highlighted in red on Figure 72).

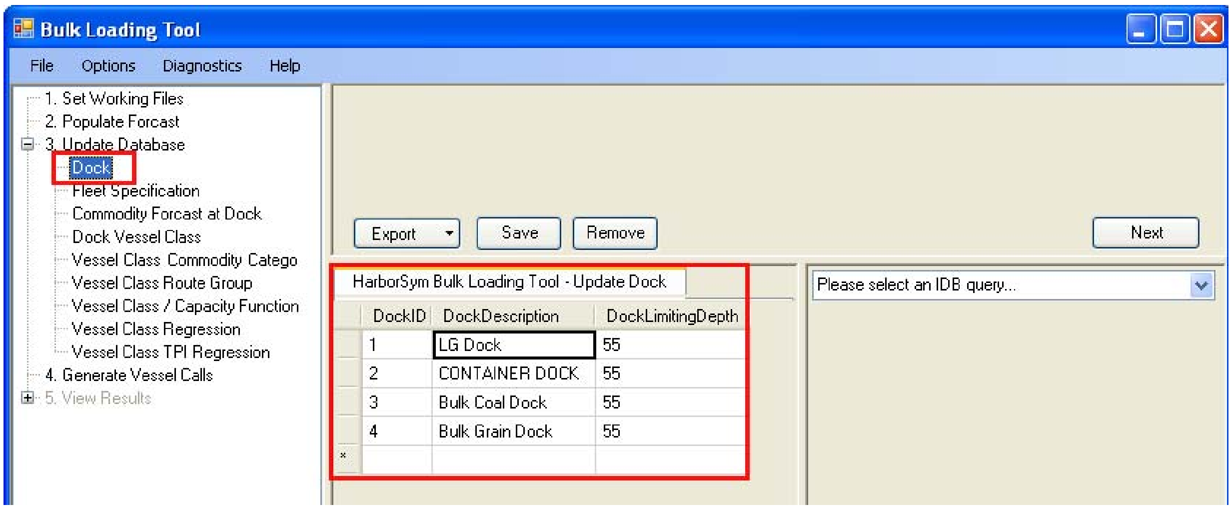


Figure 72: BLT Update Database

To aid the user in recalling IDB data specifications, a query form is provided in the far right of the BLT data pane. The query form allows the user to view additional details on Docks, Vessel Type, Vessel Class, Commodity Categories, and Route Groups. The query form is shown in Figure 73. The data shown in the query tables are only for viewing and cannot be edited.

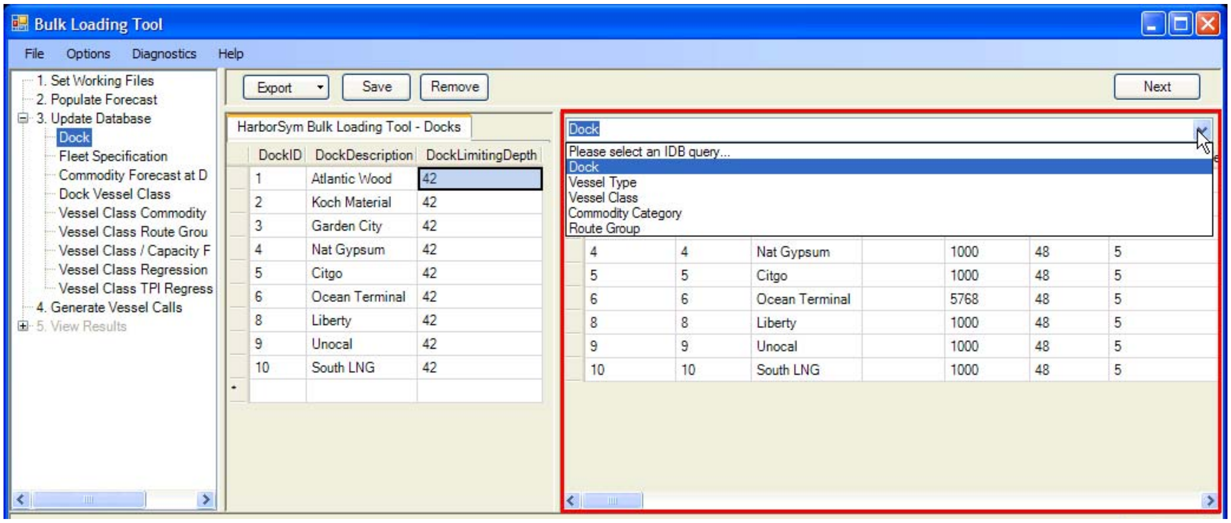


Figure 73: BLT--Review IDB Data Using Query Form

If the project-related IDB and an historical VCDB was used to populate the FCDB, then each table must be reviewed and edited to reflect the future synthetic fleet and commodity forecast for bulk traffic only. If the IDB and VDCB for the HarborSym project used to populate the forecast has a containerized vessel type with classes and containerized cargo commodity group, then the tables provided under 'Update Database' in the BLT should be edited to remove any reference to containerized vessels or commodities carried solely by containerships.

Delete rows by following the steps shown in Figure 74. Begin by selecting the record(s) that you would like to delete. You can sort by the fields (such as Vessel Class ID) to arrange the data in a way that multiple records can be deleted at a time. Next, click the 'Remove' button. A prompt will appear asking if you would like to delete the selected row(s), as shown in Step 3. Click 'OK'. You will be prompted again to confirm that you would like to delete the row, click 'Yes'. For each row that is selected to be deleted, the user will have to confirm the deletion. As shown in Step 5, the user must click 'Save' in order for the changes to be permanent in the FCDB.

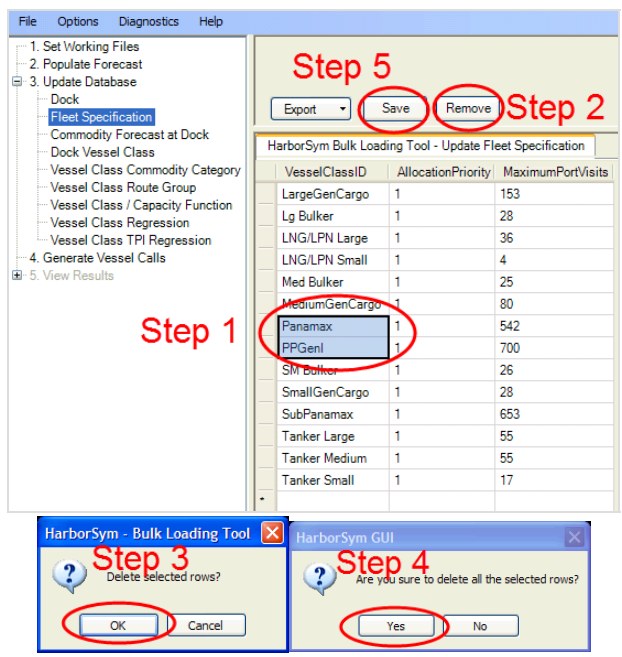


Figure 74: Delete References to Container-related Data in BLT

The user must click save after editing data in any of the tables.

All tables must be updated to properly reflect the future fleet and commodity forecast for generalized bulk traffic. Data fields within each table should be carefully reviewed and understood prior to moving to the next step. Forecast data for a new commodity exchanged at the docks or new vessel class calling the port must be manually entered by selecting from the drop down menus provided and entering required data. Data tables were designed so that data can be edited as appropriate but some grids have editing restrictions to ensure data consistency between the generated VCDB and the HarborSym project. The following provides notes for each data table.

- Dock information must be entered through the HarborSym user interface. The user is not able to add a new dock through the BLT, remove a dock, or change the dock depth. If the future condition will have a new dock available then the linked IDB should have the dock added through the HarborSym UI.
- The Fleet Specification table is fully editable by the user. This data is populated based on the VCDB. Thus, data are a reflection of the conditions present in the linked VCDB (more than likely historical conditions). References to containerships should be deleted. Allocation priorities and maximum port visits should be updated to reflect fleet characteristics for the forecast year. If the user created a new vessel class in the linked IDB that did not call the port during historical conditions, the user can select the vessel class from the drop down menu and enter an allocation priority and the maximum number of port visits.
- The Commodity Forecast at Dock table is fully editable by the user. This data is populated based on the VCDB. Thus, data are a reflection of the conditions present in the linked VCDB (more than likely historical conditions). Import and export quantities (in metric tons) should be updated to reflect the forecast year. References to any commodity that is for carried solely by containerships should be deleted. If the user created a new commodity type in the linked IDB that was not exchanged at the port during historical conditions, the user can select the commodity type from the drop down menu, select a dock that it is handled at, and enter the import and export forecast.
- The Dock Vessel Class table is fully editable by the user. This data is populated based on the VCDB. Thus, data are a reflection of the conditions present in the linked VCDB (more than likely historical conditions). This grid should be updated to reflect conditions expected during the forecast year. References to containerships should be deleted. If the user created a new vessel class in the linked IDB that did not call the port during historical conditions, the user can select the vessel class from the drop down menu and select the Dock it is assumed to visit.
- The Vessel Class Commodity Category table is fully editable by the user. This data is populated based on the VCDB. Thus, data are a reflection of the conditions present in the linked VCDB (more than likely historical conditions). All data requirements should be updated to reflect the forecast year. References to containerships should be deleted. If the user created a new vessel class and/or new commodity in the linked IDB, the user can select the vessel class from the drop down menu and select the dock it is assumed to visit, and enter the required loading data.
- It is necessary that Route Groups be consistent between the BLT-generated VCDB and the HarborSym project IDB. The Vessel Class Route Group table is therefore not editable by the user. Any edits required to future route groups by vessel class should be made to the linked IDB through the HarborSym UI.

- The data in the Vessel Class/Capacity Function table is populated from a statistical analysis routine on the linked historical VCDB. Function names are automatically generated by the BLT. References to containership vessel classes should be deleted. The X Y fields are editable by the user and should be expanded as necessary to capture larger vessels under the with-project condition (for deepening studies only). The user cannot add new rows to the grid and should use the rows available to change the X Y data, if needed. Because the functions are developed from historical data, a function will not be populated for any new vessel class added through the IDB. The BLT will draw from vessel class attributes specified through the HarborSym UI to assign a capacity for a generated vessel.

- The data in the Vessel Class Regression table is populated from a statistical analysis routine on the linked historical VCDB. References to containership vessel classes should be deleted. Data in this grid are not editable by the user and new rows cannot be added to the grid. Because the functions are developed from historical data, a function will not be populated for any new vessel class added through the IDB. The BLT will draw from the vessel class attributes specified through the HarborSym UI to assign vessel characteristics for a generated vessel.

- The data in the Vessel Class TPI Regression table is populated from a statistical analysis routine on the linked historical VCDB. References to containership vessel classes should be deleted. Data in this grid are not editable by the user and new rows cannot be added to the grid. Because the functions are developed from historical data, a function will not be populated for any new vessel class added through the IDB. The BLT will draw from the vessel class attributes specified through the HarborSym UI to assign vessel characteristics for a generated vessel.

7.1.4 Generate Synthetic Bulk Vessel Call List

After the vessel fleet availability, commodity forecasts, and other pertinent forecast inputs and parameters have been established, the BLT can be directed to create a synthetic vessel fleet and load the commodity forecast on these vessels. The process used to generate and load vessels is described in Section 4.1.3.

Ultimately, the generation process will result in a fully populated vessel call database (VCDB) capable of supporting a HarborSym simulation. To prevent overwriting the existing vessel call database currently attached to the BLT, the tool must be directed to a blank database. This is done by clicking on Generate Vessel Calls, selecting a VCDB for creation as shown in Figure 75. Once the output VCDB is linked, the user can save this configuration if desired by selecting File/Save Config from the main menu.

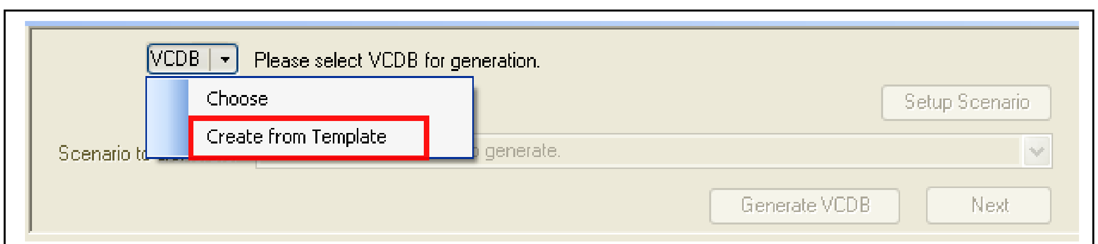


Figure 75: BLT--Create New VCDB from Template

A generation scenario must be created to define the generation parameters and track the associated outputs. This is done by clicking Setup Scenario, as displayed in Figure 76. This will launch a new window, the Forecast Scenario table, with the below fields:

- Forecast Scenario Name: the name assigned to the forecast scenario. Special care should be taken to provide a logical name for the scenario, as the name will be included in all output files generated by the scenario; without a reasonable naming schema the outputs will be difficult to differentiate.
- Forecast Scenario Description: provides a more detailed description of the forecast scenario for assistance in differentiating outputs and generated databases.
- Forecast Year: the year to be assigned to calls in the generated call list.
- Iterations: the number of iterations to be processed. Note that the BLT has the capability to produce a multiple iteration vessel call database. This number must correspond to the number of iterations desired for the HarborSym simulation and thus the number of iterations ran using the CLT.
- Write to Vessel Call Database: activating this check box will populate the attached vessel call database (VCDB) with the generated data. The user may desire to run a number of simulations without writing to the VCDB to speed up the process of testing the data. Once data inputs are finalized, the user will want to activate this box in order to generate a VCDB that can be utilized by HarborSym.
- Seed: used to start the Monte Carlo simulation; this value should be greater than 0.
- Generation Period: number of days to generate a call list for, typically 365.

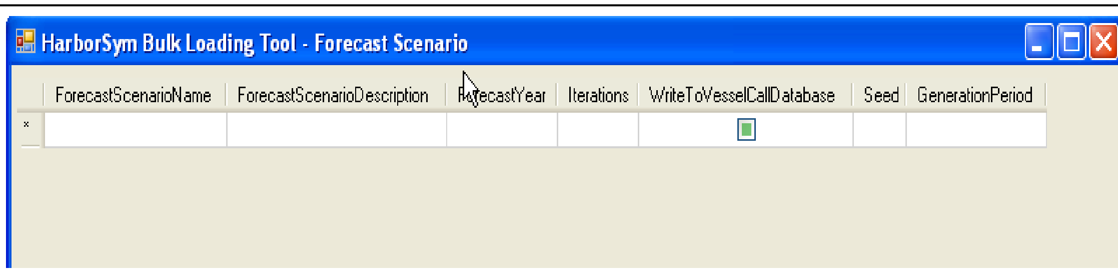


Figure 76: BLT—Setup Scenario

After creating and saving the forecast scenario, this screen can be closed. The newly created scenario will appear in the pull down menu under “Scenario to Generate”. The scenario can be launch by selecting it from the pull down menu and activating “Generate VCDB”.

7.1.5 View Results

The generation process, as described in Section 4.1.3, attempts to load the forecasted commodities on the available vessel fleet generated based on the user specifications. The successful loadings are formatted into a vessel call database fully compatible with HarborSym. It is anticipated that the process of creating and loading a synthetic shipment list will be iterative. That is, reasonably

matching the estimated number of vessel calls by class with the forecasted commodity imports and exports may require multiple revisions to the input data. If results are not within a reasonable range, the user should review all data inputs and assumptions for errors or inconsistencies. Reviewing the list of generated vessels paying special attention to the physical characteristics of the vessels is a good starting point.

The BLT module provides robust outputs to identify unsatisfied demands and demonstrate problems with the user provided loading patterns and vessel statistics. Several of these outputs are viewable through the BLT user interface and can be exported to a csv or html file and saved, including:

- Allocations: a description, by commodity and dock, of the import / export forecasts, quantity of import / export demand satisfied, quantity of import / export demand unsatisfied, and number of vessel calls.

- Generated Vessels: a listing of all unique vessels generated, including the assigned physical characteristics of LOA, beam, capacity, TPI factor, and design draft.

- Generated Calls: the vessel call list generated to satisfy the forecasted commodity demands, including the vessel name, arrival date and time, arrival draft, route group assignment, dock visited, commodities transferred, and ETTC (estimate of total trip cargo). Users should be aware that ETTC is populated by the BLT in a manner that will always produce 100% allocation of at-sea sailing costs to the subject port. If the user has information that the vessel arrives at the subject port with cargo that is destined for another port, the ETTC field must be manually adjusted upward accordingly. See Section 3.3.1 for complete details on how the ETTC field is used in HarborSym.

Additional detailed outputs are produced during the generation and are stored in the same location as the forecast database (FCDB). The user may also view the generated VCDB using Microsoft Access or the HarborSym user interface (select ‘Port Traffic’ in the tree node once the VCDB has been attached to a HarborSym project).

7.2 Create Synthetic Containership Vessel Call List Using Container Loading Tool

The CLT was developed to assist users in generating a synthetic future vessel call list for containership vessels. The CLT is launched from the HarborSym Tools menu, as shown in Figure 77. The following sections outline the steps to create a synthetic call list for containerized vessel traffic using the CLT. The end result of the process will be a fully populated VCDB that can be used directly by HarborSym. The CLT-generated VCDB must be combined with the BLT-generated VCDB using the Combiner module if non-containerized traffic is modeled in the analysis.

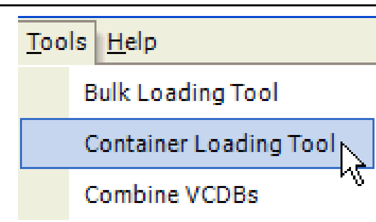


Figure 77: Launch Container Loading Tool

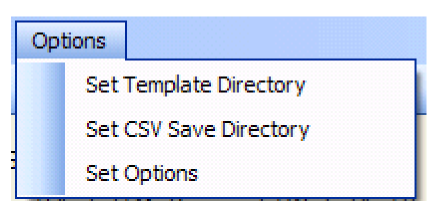


Figure 78: Set CLT Template Directory

7.2.1 Set Template and Save Directories

Upon first using the CLT, or if a new install for HarborSym has been provided, the user will need to set the template directory for creating blank CFCDBs and VCDBs. This is done by selecting Options/Set Template Directory from the main menu, as shown in Figure 78. A dialog will open to specific the location of the HarborSym templates installed with the software. This will be located in the directory where the program files were installed. See Section 2.3 for the location of the Template Directory.

Through the Options menu, the user can also specify a directory where CSV exports are saved. If this directory is not specified, the CSV file exports are saved to a temporary directory, as specified in Section 2.3.

7.2.2 Set Working Files

A single HarborSym study is composed of several distinct Microsoft® *Access* databases. Before generating synthetic call lists, users must first attach the CLT module to the appropriate master, input, vessel call, forecast, and geography databases. Table 1 (page 6) describes the different information contained in each database. Figure 79 shows the CLT screen where databases are specified. Established databases can be linked by either selecting the box next to the database or through the File menu. The File menu has additional options such as Copy Existing and Create from Template.

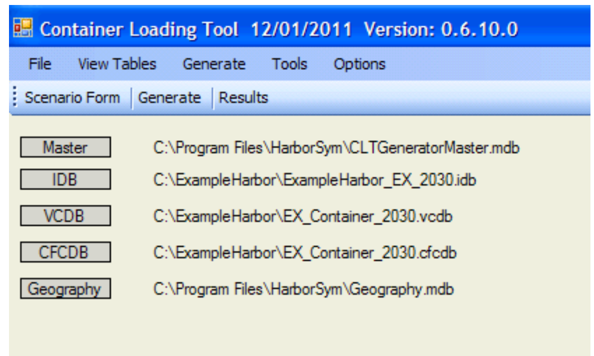


Figure 79: Attach CLT Databases

The Master database links together all relevant information needed for CLT generations. This database location should be specified first prior to specifying the additional databases. See Section 2.3 for the location of the CLT reference databases. The file is named 'CLTGeneratorMaster.mdb'. If the user resets the link to the Master database, links to the remaining databases will be broken and will need to be reestablished.

The IDB, or input database, describes project layout, including the docks, vessel types, vessel classes, commodity categories, and route groups. It is important to attach the CLT module to the correct input database as this database defines the vessel and commodity classifications that provide the basis for a synthetically generated call list. Typically, the IDB specified here will be the HarborSym IDB corresponding to the future project for which the CLT is being used to generate a synthetic VCDB.

The VCDB, or vessel call database, documents the unique vessels that call the port, and all the calls and commodity transfers made by these vessels. The CLT vessel call database generation process varies from the BLT process in that the user will direct the CLT to create a VCDB from template rather than starting with an existing condition VCDB. **That is, the VCDB specified in this step is the VCDB that will be the output of the CLT generation process.** The template directory must be set prior to creating the VCDB from template. This can be achieved through the Options/Set Template Directory menu as described above.

The next database that must be specified is the CFCDB, or containership forecast database. This database stores information about commodity forecasts at docks, the container fleet specification,

parameter settings, seasons, dock parameters and vessel class specifications, services, regions, route groups, arrival draft functions, and vessel subclasses. Initially, a blank CFCDB should be attached to the CLT. This can be done by selecting "Create from Template" from the File menu. Follow the prompts to provide a file name and save location for the new CFCDB. Again, the template directory must be specified prior to creating the CFCDB from template.

Finally, the Geography database must be specified. This database stores relational information about ports and regions. This database, in and of itself, does not contain any study-specific content. See Section 2.3 for the location of the CLT reference databases.

7.2.3 Review IDB and Geography Databases

To assure that the correct IDB has been selected, the user should review the data tables available in the IDB through the View Tables/IDB menu option, as shown in Figure 81.

Notice that the Dock Limiting Depth table name is in bold. This is to draw attention to the fact that only this table is editable through the CLT user interface. **Note: For any table launched through the View Tables menu, fields highlighted in blue are editable.** In addition to Dock depth, the user should review all data provided in these tables to ensure consistency in the CFCDB and thus CLT-generated VCDB and the HarborSym IDB that will be later be linked in HarborSym to run a port traffic simulation.

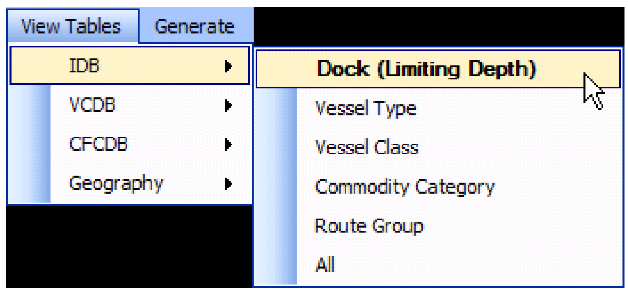


Figure 81: Review IDB Tables Through CLT Menu

At this time the user should become aware of the region assumptions inherent in the CLT's Geography database. While the Region table is currently editable by the user, it is not recommended that Regions within this table be edited. The Regions listed in this table are consistent with the regions specified in the A-DAPP tool.

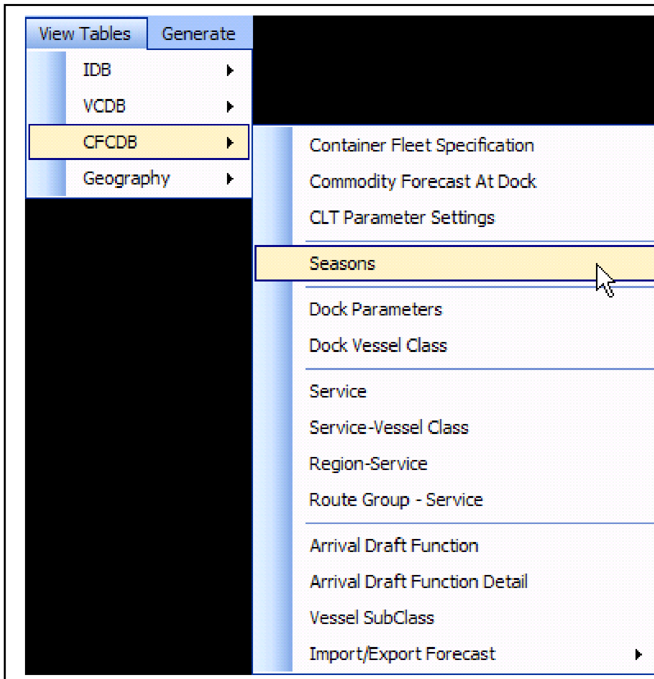


Figure 80: Edit CFCDB Tables through CLT Menu

7.2.4 Populate CFCDB with Data

The CLT requires extensive data to generate a containership synthetic future vessel call database. The tables in the CFCDB should be completed in a specific order. The following subsections provide an overview of the data required in the CFCDB. In general, these steps should be completed in the order in which the

information is presented. As the user becomes familiar with the tool and the data requirements, the steps to enter data should become more apparent.

The general order for entering data into the CFCDB is: Seasons, Dock Parameters, Dock Vessel Class, Service, Region-Service, Route Group-Service, Arrival Draft Function, Arrival Draft Function Detail, Service-Vessel Class, Vessel Subclass, Container Fleet Specification, Commodity Forecast at Dock, and CLT Parameter Settings. CFCDB data are entered through data grids accessible through the View Tables/CFCDB menu option, as shown in Figure 80.

Note that all tables in the CFCDB have a field in the first column position that provides a unique identifier for the each record in the table. Any column that is colored white is ready-only. Columns colored blue are editable by the user. All tables accessible through the View Tables menu can be exported to a CSV file by selecting the 'CSV' button in the upper-right hand of the table interface. Files will be saved to either a temporary directory or to the directory specified through the Options menu, see Section 7.2.1.

7.2.4.1 Seasons

The CLT allows the user to divide commodity forecasts and vessel availability into seasons. This allows the synthetic vessel call list to account for potential seasonal demands, such as increased toy shipments from China in preparation for the Christmas buying season. Seasons are user-defined and must cover the entire year. The user can specify as many seasons as necessary to capture unique shipping patterns inherent at the port of study. Each season is specified by a start month and day and an end month and day, as shown in Figure 82**.**

Season

select * from tblSeason

SeasonID	SeasonNumber	SeasonDescription	SeasonStartMonth	SeasonStartDay	SeasonEndMonth	SeasonEndDay
1	1	Jan-Jun	1	1	6	30
2	2	Jul-Oct	7	1	10	31
3	3	Nov-Dec	11	1	12	31

Figure 82: CLT CFCDB Seasons Table

7.2.4.2 Dock Parameters

Through this data grid, the user can specify the tidal availability for each dock in feet. The CLT will use this data to constrain how deeply drafted the containership can arrive and leave the port of study. Note that there is no duration associated with this value, it is assumed that the additional tidal value can be used by the vessel in reaching the dock. This table can automatically be expanded by selecting Tools/Expand Dock Parameters Table from the menu options. All docks within the IDB will be added to the table with "0" specified as the available tide. This value should be updated with the appropriate tide available.

7.2.4.3 Dock Vessel Class

This table identifies the vessel classes that can use a particular dock, and thus are available to satisfy forecasts at that dock. Select a Dock ID from the drop down menu and then specify a Vessel Class that can service the dock, as shown in Figure 83.

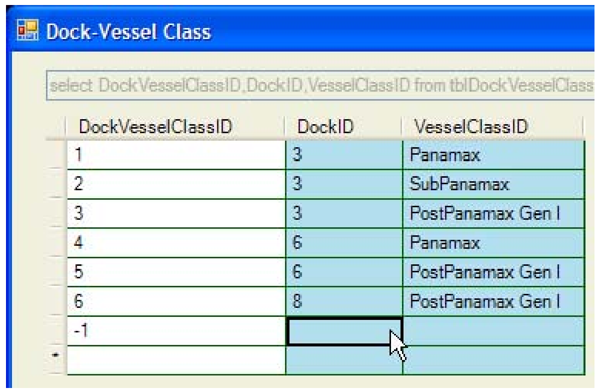


Figure 83: CLT CFCDB Dock-Vessel Class

7.2.4.4 Service

The concept of a Service plays an important role within the CLT. A service is a regular vessel transit across a set of regions. It is NOT defined at the port level. Within the geographic hierarchy in the Geography database, a port lies within a country, and a country falls within a region. Services are user-defined within the CLT, and stored in the CFCDB. Service information is available from the IWR-developed A-DAPP. Services must be given a name and description, as shown in Figure 84. The names and descriptions shown in the example were provided directly from the A-DAPP. The A-DAPP names services according to the regions visited along the service. Each letter in the Service Name corresponds to a Region found in the Geography database. Maintaining this naming convention will simplify data entry in other tables associated with regions.

Service

select * from tblService

ServiceID	ServiceName	ServiceDescription
1	ck	Mediterranean-U.S. East Coast
2	cqk	Mediterranean-Canada East Coast-U.S. East Coast
3	dsks	North Asia-Panama Canal-U.S. East Coast-Panama Canal
4	ekc	Europe-U.S. East Coast-Mediterranean
5	gt	South Asia-Suez
6	hgtk	Southeast Asia-South Asia-Suez-U.S. East Coast
7	jhgtk	Mid East-Southeast Asia-South Asia-Suez-U.S. East Coast
8	kb	U.S. East Coast-East Coast South America
9	ke	U.S. East Coast-Europe

Figure 84: CLT CFCDB Service

7.2.4.5 Region-Service

The region-service table identifies the regions that are visited by a particular service, as shown in Figure 85. The order in how it is entered into the table is not important. This table allows the CLT to identify all of the services that can be used to satisfy a particular forecast for a given region. First the user will select a Service ID from a drop down menu and then select a Region ID that corresponds to service. All regions visited within a service should be specified in the matrix. In the example provided in Figure 85, the Service 'ck' visits two regions (notable from the two character length of the name), U.S. East Coast and Mediterranean.

Note that the region containing the port of study will only need to be specified for a service if that region has an import/export forecast from the port of study. For example, if the port of study "Example Harbor" is located along the U.S. East Coast, the U.S. East Coast will only need to be specified as a region visited by the service if there is an import coming from or export going to a different port also located within the U.S. East Coast region.

Region - Service

select * from tblRegionService

RegionServiceID	ServiceID	RegionID
1	ck	U.S. East Coast
2	ck	Mediterranean
3	cqk	Mediterranean
4	cqk	Canada East Coast
5	cqk	U.S. East Coast
6	dsks	North Asia

Figure 85: CLT CFCDB Region-Service

7.2.4.6 Route Group-Service

The Geography hierarchy has route groups as a subset of services. That is, a service, which is defined at the region to region level, can have many route groups, which are defined at the abstract port to abstract port level. The Route Group – Service assignment table associates route groups with services, and defines a numerical value indicating how many calls assigned to the service should be assigned to the specific route group, as shown in Figure 86. As an example, 25 percent should be entered as “25”. The Percentage Assignment field will accept decimal values but note that the percentage assignment of route groups should add up to 100 for each service. This is not currently checked by the user interface Generate/Check function so the user should ensure the summation. To populate the table, the user first selects the Service from the drop-down menu, then an associated Route Group from the drop down menu, and finally specifies the percentage.

Route Group - Service

select *from tblRouteGroupService

RouteGroupServiceID	ServiceID	RouteGroupID	PercentageAssignment
3	FE	FE (Suez) ECUS	50
4	FE	FE (PC) ECUS	50
5	EU	ECUS EU	100
-1	MED	ECUS MED	100
-1	SA	ECUS NA	100

Figure 86: CLT CFCDB Route Group - Service

7.2.4.7 Arrival Draft Function

Within the CLT context, the user may either specify a minimum/maximum arrival draft for a vessel class on a given service, in which case the generation process selects randomly between the two values to assign arrival draft to a vessel, or the user may specify a cumulative distribution function (CDF) of arrival drafts, in which case the generation process uses the CDF to randomly assign the arrival draft. If the CDF option is desired, the user first specifies the CDF function names through the Arrival Draft Function table, as shown in Figure 87. The user may have a single CDF functions for all containerships or wish to specify CDF functions for each containership class. In either case, the user must also specify the minimum/maximum arrival draft in the Service-Vessel Class grid. These values are used as a data check during the CDF draw process.

Function Description

SELECT tblFunctionDescription.FunctionDescriptionID, FunctionName, FunctionDesc

FunctionDescriptionID	FunctionName	FunctionDescription
5	SubPanamax	Subpanamax vessel CDF
6	Panamax	Pananmax vessel CDF
7	PostPanamax Gen I	PPGenI vessel CDF

Figure 87: CLT CFCDB Arrival Draft Function When Utilizing CDF Functions for Vessels

If the user wishes to specify the minimum/maximum values for arrival draft of the synthetic vessel fleet, then a NULL function should be created in the Arrival Draft Function table, as shown in Figure 88. Note that the Function Name must be exactly as shown, "NULL". A function description can be provided if desired.

FunctionDescriptionID	FunctionName	FunctionDescription
1	NULL	

Figure 88: CLT CFCDB Arrival Draft Function When Utilizing Min/Max Arrival Draft for Vessels

7.2.4.8 Arrival Draft Function Detail

Through this data grid, as shown in Figure 89, the user specifies the CDF data points (X,Y) for vessel arrival drafts. The X value represents the arrival draft and the Y value represents the cumulative probability of vessel arriving at that draft. Data can be entered into this grid in two ways. First, Tools/Expand Function Table can be selected from the menu options. When this is selected, the CLT will automatically provide 20 X,Y data entries for each function description provided in the Arrival Draft Function table. Each X value will automatically be set at "0" and each X,Y pair should be updated by the user. Alternatively, the user can manually select the function description from the drop down menu and input each X,Y pair. CDF data on containership arrival draft for a given port are available from the A-DAPP. **Note that the CDF functions should be expanded in the with-project analysis to reflect the vessels drafting according to the deepened channel depth.** No CDF function details need be provided if the user desires to use the minimum/maximum arrival draft.

Arrival Draft Function

SELECT tblFunction.FunctionID, tblFunction.FunctionDescriptionID,

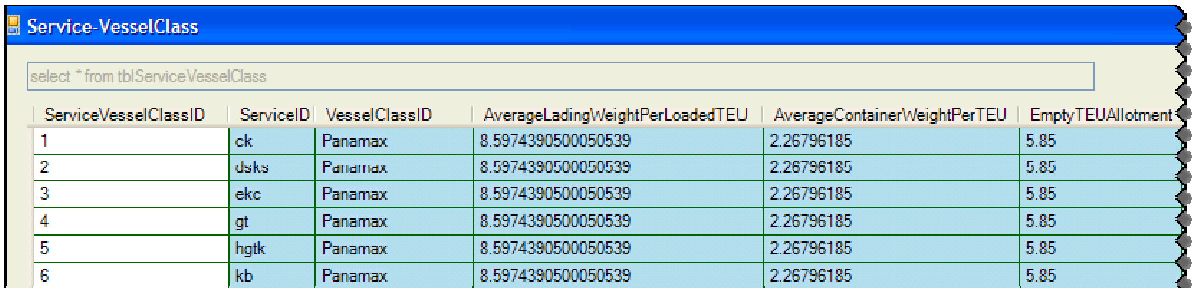
FunctionID	FunctionDescriptionID	X	Y
126	SubPanamax	26.247	0.009
127	SubPanamax	26.575	0.014
128	SubPanamax	27.559	0.019
129	SubPanamax	27.887	0.028
130	SubPanamax	28.215	0.037
131	SubPanamax	28.543	0.051

Figure 89: CLT CFCDB Arrival Draft Function Detail When Utilizing CDF Functions for Vessels

7.2.4.9 Service-Vessel Class

The concept that different services and vessel classes have different container loading characteristics is basic to the CLT, in particular the loading factor analysis (LFA) and determination of vessel arrival drafts. This information is captured in the Service-Vessel Class table. Three basic types of information

are stored: 1) information for use in determination of arrival draft; 2) information for use in the loading analysis; and 3) information for use in determining the fraction of the vessel load on arrival



Service-VesselClass

select * from tblServiceVesselClass

ServiceVesselClassID	ServiceID	VesselClassID	AverageLadingWeightPerLoadedTEU	AverageContainerWeightPerTEU	EmptyTEUAllotment
1	ck	Panamax	8.5974390500050539	2.26796185	5.85
2	dsks	Panamax	8.5974390500050539	2.26796185	5.85
3	ekc	Panamax	8.5974390500050539	2.26796185	5.85
4	gt	Panamax	8.5974390500050539	2.26796185	5.85
5	hgtk	Panamax	8.5974390500050539	2.26796185	5.85
6	kb	Panamax	8.5974390500050539	2.26796185	5.85

Figure 90: CLT CFCDB Service – Vessel Class

that is imported/exported to the subject port. The data grid can be initially expanded to provide a row for each Service ID and Vessel Class ID by selecting Tools/Expand Service Vessel Class Table from the main menu. Otherwise, the user may manually populate the data grid by selecting a Service ID and associated Vessel Class ID from the drop down menus provided in the cells of these fields. An example Service-Vessel Class table is provided in Figure 90.

A great deal of data must be entered into the Service - Vessel Class table. Each data field requirement for vessel class by service is described in Table 5. Analyst should contact the Deep Draft Navigation Center of Expertise (DDNPCX) or IWR for data regarding Empty TEU Allotment, Vacant Slot Allotment, Allowance for Ops, and Variable Ballast.

Table 5: CLT CFCDB Service - Vessel Class Table Field Descriptions

FIELD	DESCRIPTION
AverageLadingWeightPerLoadedTEU	Average commodity weight per loaded TEU in metric tons; data available from W-DAPP
AverageContainerWeightPerTEU	Average weight of the TEU container when empty in metric tons
EmptyTEUAllotment	Number of empty TEUs allotted
VacantSlotAllotment	Number of vacant slots allotted
AllowanceForOperations	Allowance for operations typically varies by vessel size. Allowance for operations represents tonnage used for bunkerage (fuel) and ships stores. The unit is a user-specified percentage of the available dead weight tonnage at the vessel arrival draft (e.g., enter 15 percent as 15).
VariableBallast	Variable ballast is the substance placed in the hold of a ship to enhance stability. The unit is a user-specified percentage of the available dead weight tonnage at the vessel arrival draft (e.g., enter 15 percent as 15).
MinimumArrivalDraft	Represents the minimum draft of vessels when arriving at the port. If the CDF function is utilized, then minimum arrival draft values should be the lower bound of the CDF values
MaximumArrivalDraft	Represents the maximum draft of vessels when arriving at the port. If the CDF function is utilized, then maximum arrival draft values should be the upper bound of the CDF values

FIELD	DESCRIPTION
FunctionDescriptionID	Select the CDF function from the drop down list for the Service/Vessel Class combination; if only the minimum/maximum arrival draft values are utilized and no CDF function is available, then the CDF function "NULL" should be selected (NULL created through the Arrival Draft Function grid)
ImportFractionDistributionParameterP1	Fraction of total imported tons to ship capacity, minimum value (example: 250/1000 (or 25%) as 0.25)
ImportFractionDistributionParameterP2	Fraction of total imported tons to ship capacity, most likely value ((example: 250/1000 (or 25%) as 0.25)
ImportFractionDistributionParameterP3	Fraction of total imported tons to ship capacity, maximum value (example: 250/1000 (or 25%) as 0.25)
ExportFractionDistributionParameterP1	Fraction of total exported tons to ship capacity, minimum value (example: 250/1000 (or 25%) as 0.25)
ExportFractionDistributionParameterP2	Fraction of total exported tons to ship capacity, most likely value (example: 250/1000 (or 25%) as 0.25)
ExportFractionDistributionParameterP3	Fraction of total exported tons to ship capacity, maximum value (example: 250/1000 (or 25%) as 0.25)

7.2.4.10 Vessel Subclass

Within the CLT process, a vessel call is created based on a vessel class. Specific vessel characteristics are determined by choosing a vessel from the vessel subclass table. The subclass table provides standard vessel data for sets of vessels within a given vessel class. This information has been defined by IWR for containerships, with 45 distinct subclasses for 4 vessel classes (SubPanamax, Panamax, PostPanamax Gen1, and PostPanamax Gen2), and should not be changed by the user. The proportional assignment of vessel subclasses to a class is a user-entered parameter. The only field that should be edited by the user is the percentage of subclass assignment to the vessel class (enter 25% as 25). The total percentage within a class should sum to 100.

Table 6: CLT Vessel Subclass Field Definitions

HEADING	DESCRIPTION
VesselSubClassID	Automatically generated unique identifier
VesselClassID	Drop down menu options to select the Vessel Class that corresponds to the Vessel SubClass description
VesselSubClassDesignator	Automatically generated value
VesselSubClassDescription	CLT-provided vessel sub-class description, standardized by IWR
LOA	Length overall in feet
LBP	Length between perpendiculars in feet
Beam	Beam in feet
MaximumSLLD	Maximum summer loadline draught
Capacity	Vessel capacity in DWT
AppliedDraftClass	Draft range for subclass in feet
TEURating	Twenty-foot equivalent unit rating for vessel subclass
TPIFactor	Tons per inch immersion factor for vessel subclass
BaselineUnderkeelClearance	Underkeel clearance in feet
SinkageAdjustment	Adjustment for sinkage in feet
PercentageOfClass	User defined percentage of vessel subclass to vessel class

7.2.4.11 Container Fleet Specification

A fleet specification is defined as a maximum number of port visits within a given season of a vessel of a given class, operating on a particular service, as shown in Figure 91. A specification essentially says: "In the first 6 months of the year, there are 45 available calls of Panamax vessels operating on the East Coast US – Mediterranean Pendulum service". An allocation priority is assigned to individual fleet specifications, and the CLT observes these priorities, attempting to fill a forecast by using vessels from the fleet with the highest allocation priority before using vessels of a lower priority. Note that the highest allocation priority is 1, the larger the number, the lower the priority.

Container Fleet Specification

select * from tblContainerFleetSpecification

ContainerFleetSpecificationID	ContainerFleetSpecificationDescription	ServiceID	VesselClassID	SeasonID	AllocationPriority	MaximumPortVisits
1	Service 1, VessClass 39, Season 1	ck	Panamax	Jan-Jun	2	45
2	Service 1, VessClass 39, Season 2	ck	Panamax	Jul-Oct	2	25
3	Service 1, VessClass 39, Season 3	ck	Panamax	Nov-Dec	2	10
4	Service 1, VessClass 40, Season 1	ck	SubPanamax	Jan-Jun	3	50
5	Service 1, VessClass 40, Season 2	ck	SubPanamax	Jul-Oct	3	35
6	Service 1, VessClass 40, Season 3	ck	SubPanamax	Nov-Dec	3	20
7	Service 1, VessClass 41, Season 1	ck	PostPanamax Gen I	Jan-Jun	1	50
8	Service 1, VessClass 41, Season 2	ck	PostPanamax Gen I	Jul-Oct	1	40
9	Service 1, VessClass 41, Season 3	ck	PostPanamax Gen I	Nov-Dec	1	20
10	Service 2, VessClass 41, Season 1	cqk	PostPanamax Gen I	Jan-Jun	1	25
11	Service 2, VessClass 41, Season 2	cqk	PostPanamax Gen I	Jul-Oct	1	40

Figure 91: CLT Container Fleet Specification

7.2.4.12 Commodity Forecast at Dock

Forecasts are defined at the commodity, dock, season, and region level, as import and export quantities in metric tons as shown in Figure 92. A forecast name should be provided (e.g. "FC1") for use in referencing output to a particular forecast. In addition to the expected import and export quantity, standard deviations (also in metric tons) should be provided for each forecast unit combination. Standard deviations for the import/export forecast are used by the CLT to select an import/export quantity during the Monte Carlo simulation.

Commodity Forecasts By Dock and Region

select * from tblCommodityForecastByDockRegion

Commo...	Comm...	CommodityCategoryID	DockID	SeasonID	RegionID	ImportQuantity	ExportQuantity	ImportQuantitySD	Exp
141	1	General Cargo	3	Jan-Jun	Caribbean / Gulf	104000.78493669906	188797.46774602667	520.00392468349526	943.
142	2	General Cargo	3	Jul-Oct	Caribbean / Gulf	124739.85497889559	137815.33718045286	623.699274894478	689.
143	3	General Cargo	3	Nov-Dec	Caribbean / Gulf	39749.974095283105	55555.118550688916	198.74987047641554	277.
144	4	Chemical Products	3	Jan-Jun	Caribbean / Gulf	7361.261668310789	10021.190956605322	36.806308341553944	50.1
145	5	Chemical Products	3	Jul-Oct	Caribbean / Gulf	6953.1031565922858	18946.082113957251	34.76551578296143	94.7
146	6	Chemical Products	3	Nov-Dec	Caribbean / Gulf	2315.6978894738027	4904.244590285407	11.578489447369014	24.5

Figure 92: CLT Commodity Forecasts by Dock and Region

7.2.4.13 CLT Parameter Settings

This table is designed to store, in a tag-value format, information for the simulation. The tag-value format is easily extended as new port-wide values are incorporated in the CLT algorithms. At present, the only value in this table is for a port-wide sea level change value. Sea level change is applied uniformly to all docks within the port. If the user wishes to utilize the sea level parameter in the CLT, please take care that the Route Group prior and next port limiting depth reflects the sea level change as well.

7.2.5 Specify and Set Scenario

Once all data have been entered into the CFCDB, the user should specify the scenario parameters through the Scenario Form, accessed through the Generate/Scenario Form menu option or the Quick Access Bar. The Scenario Form, shown in Figure 93, allows the user to specify a name, the forecast year, the number of iterations desired, and a seed number. The user should set the “WriteToVesselCallDatabase” field to True if a VCDB generation is desired. The user may want to test data assumptions prior to generating a VCDB. The “DebugFlag” field is for CLT developer use and should be set to False under normal circumstances. Note that the number of iterations must be compatible with the number of iterations ran in the BLT and the number desired in the HarborSym study.

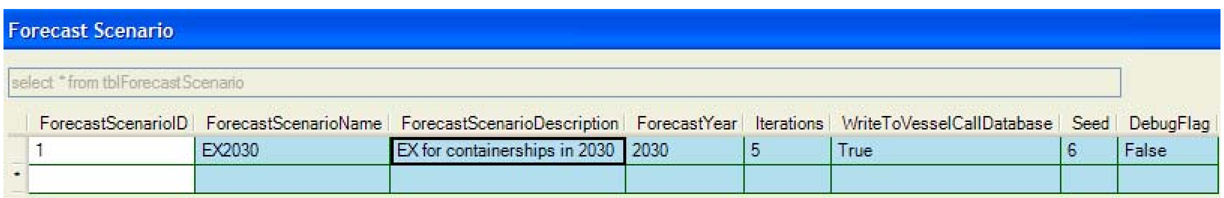


Figure 93: CLT Scenario Form

Once the desired scenario is specified, the user should set the scenario for generation through the menu option Generate/Set Scenario/Set Forecast Scenario. Be certain to click Save after selecting the desired scenario.

7.2.6 Data Check

A small number of data checks have been implemented through the CLT user interface. This option is available from the menu option Generate/Check. Any issues identified through the data check should be resolved prior to generating a VCDB.

7.2.7 Generate VCDB

Once all data have been entered into the CFCDB, the scenario parameters have been defined, and the data check returns no errors, the user can generate a containership vessel call forecast. Selecting the Generate button from the user interface will begin the process. During each season, the satisfaction of each forecast and the fleet utilization is shown graphically. Each individual graph can be manipulated (zoom/pan) and the image saved, by right-clicking on the graph to get a context menu. Feedback is

provided regarding what iteration and what stage within the iteration the CLT is currently processing. The graphic display may be turned off through the Option/Set Options menu.

Generation of a complete and balanced VCDB for containerships may require multiple generations and data adjustments. Results should be reviewed to test forecast assumptions and adjustments made as needed. Note that the CLT will not process a VCDB if any data errors are present in the CFCDB. If the generator does not process, return to the CFCDB tables and review all data.

7.2.8 View Results

Once the CLT has finished processing the loading simulation, a number of output files are available for the user.

- PRN File: This file is lightly populated. It will eventually contain summary information for the scenario run on fleet specification usage and forecast satisfaction.

- ECH file (echo): This file is intended to provide a record of input data read from the database. It is only partially populated at this time.

- DBG file (debug): The debug file provides information for analyzing the container loading process. It is intended primarily for developers, not end users.

- Generated VCDB: The fundamental goal of the CLT is to generate a VCDB that reflects the specified fleet availability, forecasts, and depth constraints. The generated VCDB can be run through a HarborSym simulation to estimate congestion effects and cost allocation to the subject port.

- Output Tables in the CFCDB: The CLT writes three tables into the CFCDB. Each of these tables can be viewed from the interim UI, in the standard data grid format:

  - Allocation results giving the export and import deficits by forecast, together with the number of unique vessels used to satisfy each forecast.

  - Fleet usage specification results, showing the maximum provided port visits, and the visits used by the allocation process.

- PNG files with the seasonal fleet usage and forecast satisfaction graphics that display during VCDB generation.

Commodity transfer results, providing import/export information for each forecast specified by each vessel. Note the shaded rows where a single vessel is satisfying two different forecasts.

7.3 Combine VCDBs

Given the nature of the HarborSym database structure, the BLT and CLT-generated vessel call lists must be combined into a single vessel call list for cases where both types of traffic are to be modeled. The Combiner module was developed to address this need.

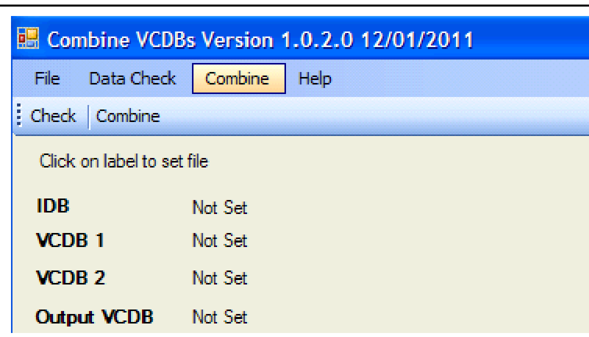


Figure 94: Combine VCDBS

The Combiner is quite simple to use. The user specifies the IDB that corresponds to the VCDBs that are to be combined. This should be the HarborSym IDB for the given year and with or without project status. The user then specifies the BLT-generated VCDB and CLT-generated VCDB under either VCDB 1 or VCDB 2, shown in Figure 94. When the user selects the Output VCDB, a dialog box will appear allowing the user to specify a directory and name for the combined VCDB. Once all databases are set, the user can perform a data check using the main menu option. Any noted discrepancies should be resolved prior to combining the VCDBs. The user merges the VCDBs into a single database by selecting the menu option Combine.

The user must be certain the two VCDBs selected have an equal number of iterations. Once the generation is complete, the combined VCDB should be linked to the proper HarborSym project through the File/Study Manager menu option. See Section 6.1.3, for details on how this is accomplished.

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Section 8

Simulation Settings, Run Parameters, and Scenarios

HarborSym estimates transportation costs by simulating vessel movements through the harbor based on user specified parameters. The port conditions are specified by defining projects. The timing and conditions of the simulations are defined by the user through the run parameters. Run parameters are stored within HarborSym in scenarios.

Harbor improvement projects typically are intended to improve transportation efficiency by lowering vessel transit times. Harbor improvements can also result in transportation efficiency gains by allowing vessels to carry more cargo into the harbor. In HarborSym, a new project is created to represent the harbor with improvements. The new project can be cloned from the original project after the node network for the original project is completed. The original project and all alternative projects are stored within the same HarborSym study.

A simulation of vessel traffic within a harbor is launched using a scenario. A scenario is the term used to describe a particular combination of data sets and simulation parameters selected by the HarborSym user. A scenario describes the "Run Parameters" of the simulation. During a simulation, the vessel traffic is routed through the node network based upon historical or synthetically generated vessel traffic for the period of time defined in the scenario. In HarborSym, vessels arrive at the harbor knowing their intended docks and commodity transfers, but with limited knowledge of the harbor conditions. A "harbor supervisor" acting within the simulation has complete knowledge of all scheduled movements within the harbor and approves travel through legs based upon harbor conditions, rules, and traffic. Vessel traffic is routed through legs based upon the first arrival having priority, with exceptions for protocol vessels.

8.1 Simulation Setting

The HarborSym user has the option to set several parameters to refine the simulation processing, as displayed in Table 7. These fields are accessed through the Configuration Settings window under the Simulation tab (Section 5.1.2 provides information on where to access the Configuration Settings window).

Table 7: Simulation Settings Fields

Field	Description	Value
Vessel Draft Limit_Tidal Time Interval	The controlling depth for a leg is based on available depth in the reaches of the leg, as adjusted by tide, and is used in setting the outbound draft on dock departure. The period over which the tide availability is calculated is the period from the departure time to the departure time plus the tidal time interval. Vessels that cannot pass within this time frame are subject to deletion (See Section 3.2.14, Tide and Section 9.3, Deleted Vessels)	Number in hours (72 hours is default value)
Vessel Draft Limit_Tidal Range Parameter	Factor for determining the tide usage in a reach. When determining the controlling depth for a reach, this parameter is used to add the associated fraction of the available tide range for the reach to the minimum available tide for the reach.	0 use minimum value of tide for each reach 1.0 use maximum value of tide for each reach Intermediate value linearly interpolated between minimum and maximum (0.75 is default value)
Vessel Leg Wait Limit_Count	Number of leg entry retries before a vessel is removed from system; a low value may delete vessels prematurely while a high value may slow simulation processing (See Section 3.2.11 and Appendix B, Transit Rules and Section 9.3, Deleted Vessels).	Default value is 50
Output Window Iteration Begin	HarborSym allows for the recording of detailed information on all iterations within the user defined range when the time step output is enabled. This allows for selective detailed examination of a portion of the simulation. This field sets the first iteration to begin detailed output reporting written to tblTimeStepOutput in the .SODA file.	Default value of (-1) begins recording at the first iteration.
Output Window Iteration End	This field sets the last iteration to begin detailed output reporting written to tblTimeStepOutput in the .SODA file.	Default value of 10000000
Output Window Duration Begin	HarborSym allows for the recording of detailed information on all iterations within the user defined range when the time step output is enabled. This allows for selective detailed examination of a portion of the simulation. This field sets the time within an iteration to begin detailed output reporting written to tblTimeStepOutput in the .SODA file.	Default value of (-1) begins recording at the beginning of the simulation.
Output Window Duration End	This field sets time within a simulation to end detailed output reporting written to tblTimeStepOutput in the .SODA file.	Default value of 10000000
Feet Per Coordinate Unit	This value is used for plotting of safety zone boundaries. Node coordinates may or may not be in feet. The within-simulation visualization is plotted based on node coordinates. Safety zone distances are in feet, so, if node coordinates are not in feet, this conversion is required to allow for drawing of the safety zone boundary around a vessel.	Default value is 1, indicating node coordinates are in feet.
Time Waiting At Entry Cost Threshold	Threshold value for determining if at sea or in port vessel operating costs should be applied based on vessel waiting time at entry point. (See Section 3.2.5)	If entry wait time < threshold value, apply sea costs Otherwise, apply port costs (2 hours is default value)
Time Waiting At Facility Node Cost Threshold	Threshold value for determining if at sea or in port vessel operating costs should be applied based on vessel waiting time at anchorage. (See Section 3.2.5)	If anchorage wait time < threshold value, apply sea costs Otherwise, apply port costs (2 hours is default value)
Time Waiting At Dock Cost Threshold	Threshold value for determining vessel operating costs while vessels wait at the dock. If dock wait time > threshold, apply threshold time at sea cost, remainder at port cost, otherwise all sea cost. (See Section 3.2.5)	If dock wait time > threshold value, apply sea costs, with the port costs applied to the remaining time Otherwise, apply all sea costs (1 hours is default value)
Hours Added to Protocol Simulation	Time, in hours, to extend the priority vessels run beyond the simulation duration to ensure all priority vessels are maintained in the full call list simulation. (See Section 3.2.5)	Number in hours (50 hours is default value)

8.2 Creating Simulation Scenarios

A scenario is a named combination of simulation run parameters. Vessel traffic is simulated in a harbor using navigation conditions described by the project and in the scenario defined by the user. Once the simulation process has been launched, the parameters specified in the scenario are retrieved to simulate traffic behavior in the harbor. Completion of a simulation yields many statistical results that can be compared to other simulations.

A simulation consists of one or more iterations. The user sets a start date and simulation duration that will apply to all iterations. For each iteration, HarborSym tracts the vessel traffic entering and exiting each reach in a harbor and maintains vessel traffic statistics. The vessel traffic statistics are available for each iteration in the output files. Additional iterations of a simulation can increase the accuracy of output, but require more processing time. Therefore, the HarborSym user must balance accuracy with processing time when determining the number of iterations in a scenario. The processing time for simulations is also impacted by the duration of the iterations, the size of the vessel call list for the harbor, and the amount of system congestion. Note that when using the BLT and CLT to develop a future synthetic vessel call list, the number of iterations specified in these tools must correspond with the HarborSym scenario.

8.2.1 Creating Simulation Scenarios

The *Scenarios* branch in the Navigation Pane is used to obtain the *Scenario Definition* data entry grid. A name and description for the scenario must be entered within the data entry grid, e.g., InitialTest, All Data, and No Rules. Your named scenario will appear in the Navigation Pane and can be selected to access a form-view of your defined run parameters. A pop-up window will appear to populate the name of the first scenario. The following input boxes allow the user to define a simulation scenario. The scenario is the collection of run parameters of the simulation, defined in the Scenario Editor, shown in Figure 95.

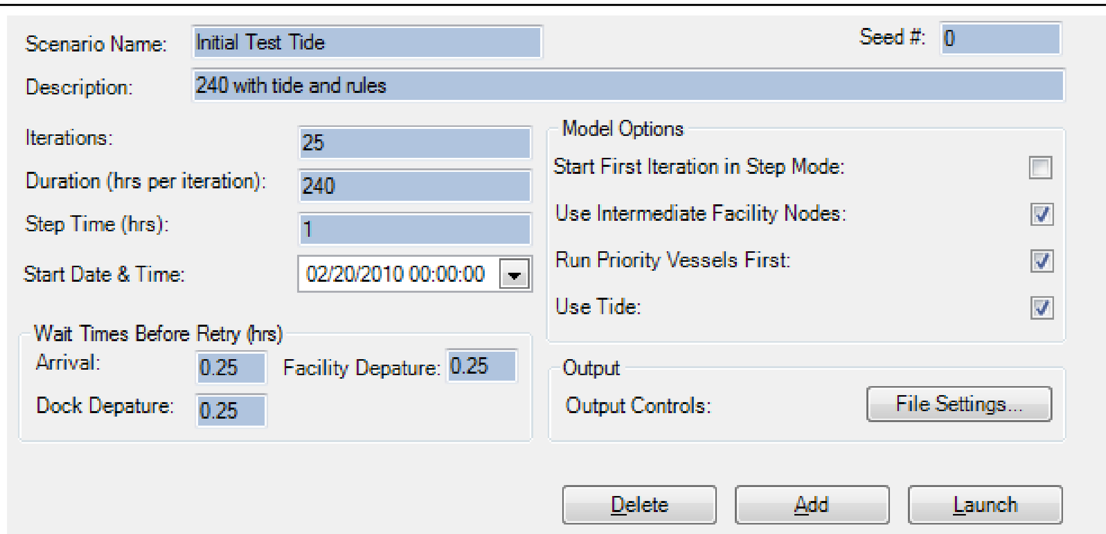


Figure 95: Scenario Editor Window in the Data Entry Pane

The fields in the Scenario Editor include:

Scenario Name	Each scenario should be named. The scenario will then be available to recall on the Navigation Pane.
Description	This block allows a scenario description that is included in output reports.
Iterations	The user determines number of iterations run during the simulation. Note that this number must correspond with the CLT and/or BLT generated vessel call database.
Duration	The length of the simulation period in hours per iteration.
Step Time	Time increment used to report vessel status during simulations (in hours) – must be greater than 0.01 hours.
Start Date	The date on which the simulation starts.
Seed Number	The number used to initialize the random number generator which determines the sequence of random numbers used during a simulation. This seed number should remain consistent for all projects due to the fact that a given seed number will produce the same sequence of random numbers every time for a given iteration. This allows comparison of a specified iteration between multiple projects.

MODEL OPTIONS:

Start in Step Mode	Step Mode provides the user with a visualization of vessel traffic in the node network during the simulation.
Use Facility Nodes	Use Intermediate Facility Nodes allows vessels to wait at specified facilities before entering a reach.
Run Protocol Vessels First	Run Protocol Vessels First provides protocol vessels priority when entering reaches. This priority impacts vessel traffic when reach rules have constraints on vessel encounters.
Use Tide	Allows tide to be used in calculating vessel draft clearances. This option must be used to activate rules that use tide.
Wait Times Retry	The length of time a vessel must wait before trying to enter a reach after a rule violation forces the vessel to wait. *Note: On the first visit of a vessel to a facility node, a wait time of 0.10 hours is automatically set for the vessel to try to depart. Subsequent departure attempts are at the user defined interval*.
Output Controls	The level of output files produced showing the results of the simulation; see Section 8 and Appendix C for details.

8.2.2 Output Control Options in the Scenario Editor Form

There are many .csv files that users can request in HarborSym and view after a simulation in Microsoft Excel, including:

Commodity.csv	DraftAdjustment2.csv
DeletedVesselCall.csv	Iteration.csv
DraftAdjustment.csv	NodeConstraint.csv
NodeScheduling.csv	RuleViolation.csv
TimeStep.csv	UnitOfMeasure.csv
Usage.csv	VesselCall.csv
VesselCallProblem.csv	VesselClassStatistics.csv
VesselsRemainingInSystem.csv	Waitcause2.csv
WaitCause.csv	RouteGroupStatistics.csv

There are also eight ASCII files available as output from a simulation; summary, vessel, event, debug, reach, rules, detailed vessel movement, and vessel post-processing animation files. The user selects the level of output for these files from the menu. Note that in order for the Vessel Time graph (available after running the simulation under the Outputs/Graphs menu option) to display the correct average vessel time, the user must select the Iteration.csv output option. Further information about these files is included in Appendix C.

8.2.3 Command Buttons in the Scenario Editor

Add	Adds a new scenario with most of the scenario parameters
Delete	Deletes current scenario. Deleting a scenario does not delete the results from that scenario run, since these are stored in a different data table.
Launch	Launch will begin the simulation and bring up the Choose Project Screen, if more than one project is in the study.

8.2.4 Choose Projects

If more than one project exists within a study, the Choose Project Screen will appear when a simulation is launched, as shown in Figure 96. With this screen, the user selects which projects to simulate by checking the box next to the project name. Buttons exist to select all of the projects listed for simulation, or to select none of the projects for simulation. After the projects are selected, the launch button must be clicked to start the simulation. The Run Simultaneous Projects option are for computers with multiple processors. When using this option, projects will run simultaneously, one per CPU.

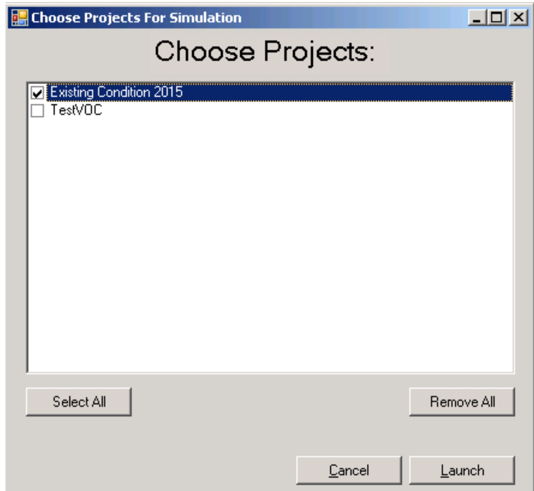


Figure 96: Choose Projects

8.3 Viewing Simulations

The HarborSym user can opt to run the simulation in step mode. This option requires more processing time for simulations, but it allows the user to visualize vessel encounters during simulations. The following paragraphs outline the necessary steps to launch the within simulation animation and describe the tool's various features.

In the Scenario Editor, click on the "Start First Iteration in Step Mode" box and click on "Launch." In the dialog box that appears, select the projects to simulate. Click on "Launch" again. A dialog box will appear stating "Starting in Step Mode Press Step Button to Continue," with an OK button. Click on "OK." The dialog box will then disappear. The screen with the dialog box is shown in Figure 97.

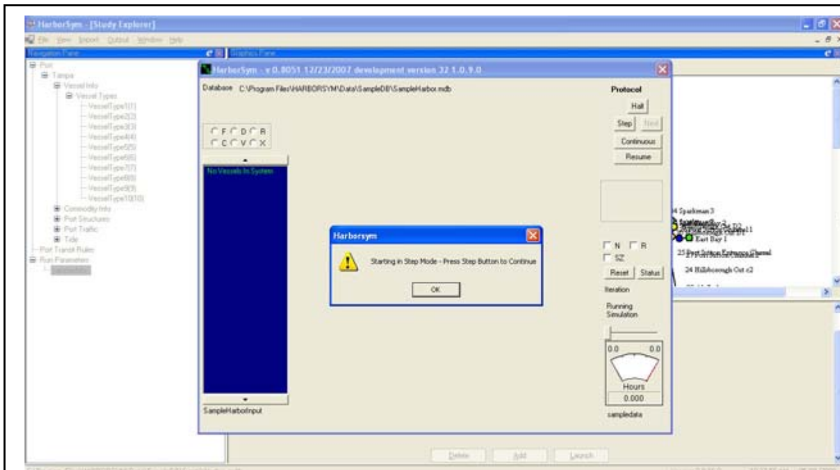


Figure 97: Dialog Box Overlaying Step Mode Screen

Click on the Step Button in the Step Mode Screen to begin the animation. To visualize vessel encounters in the next time increment, click on the Next button. Click on Continuous Button to watch the simulations continue until all iterations are complete. Click on the Halt Button to stop the simulations. Figure 98 shows the Step Mode Screen that will appear.

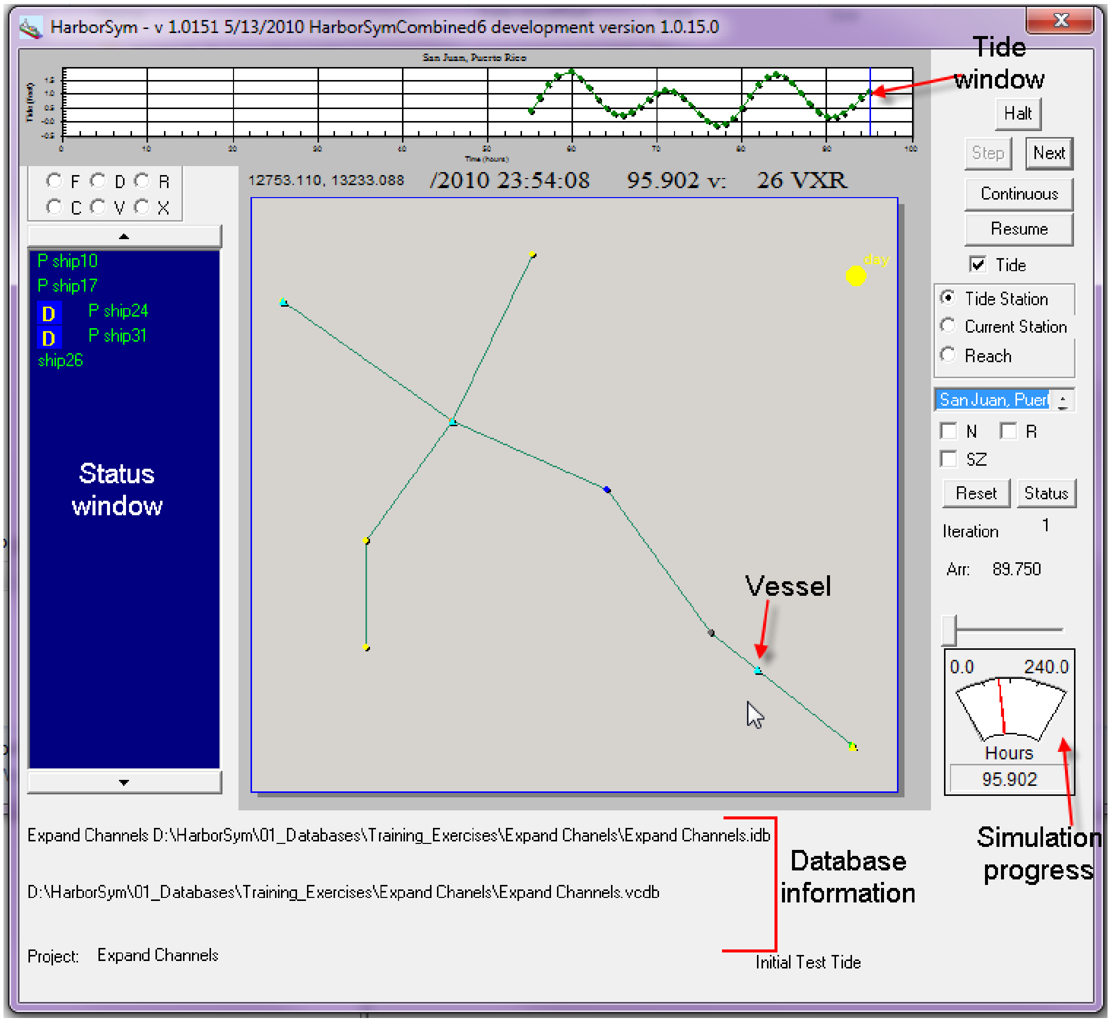


Figure 98: Step Mode Screen Showing Simulation

The within simulation animation, shown in Figure 98, displays a representation of the link-node network established in the HarborSym graphics pane. Each node type is represented with a different colored circle. Vessels are represented by colored triangles. Vessels in a delayed status (waiting at the entrance point, docks, etc.) are colored red. If tide is implemented, the graph along the top of the simulation will plot the tide height.

The Step Node Screen allows the user to modify the simulation visualization. Key features include:

- The N checkbox and the R Check Box on the right side of the screen allow the user to place the names of nodes and reaches on the screen.

- The SZ checkbox allows the user to visually see the safety zones around vessels as they navigate through the port.
- On the left side of the screen radio buttons allow the user to select between monitoring the status of commodities, docks, anchorages and turning basins, vessels, or reaches during the simulation.

  - The commodities selection (C) will show the cumulative amount of each commodity category transferred as each iteration progresses.

  - The vessel selection (V) will show the current status of each vessel, during the simulation. The vessels are listed as transiting, at a dock, or waiting.

  - The dock selection (D) lists all docks. Double-clicking on any of the entries will provide information on the dock status.

  - The reach selection (R) lists all docks. Double-clicking on any of the entries will provide information on the reach status.

  - The off selection (X) turns this feature off. This speeds up the running of the simulation.

During the simulation the user can determine the status of any vessel moving through the harbor, after clicking on the Event Button to halt the simulation. If the user clicks on the vessel representation in the node network, the vessel data sheet, including the vessel name and characteristics, will appear, as displayed in Figure 99. Additionally, users can click on the vessel name in the Status Pane to highlight the vessel location in the node. Afterwards, clicking on the Step Button or the Continuous Button will resume the simulation.

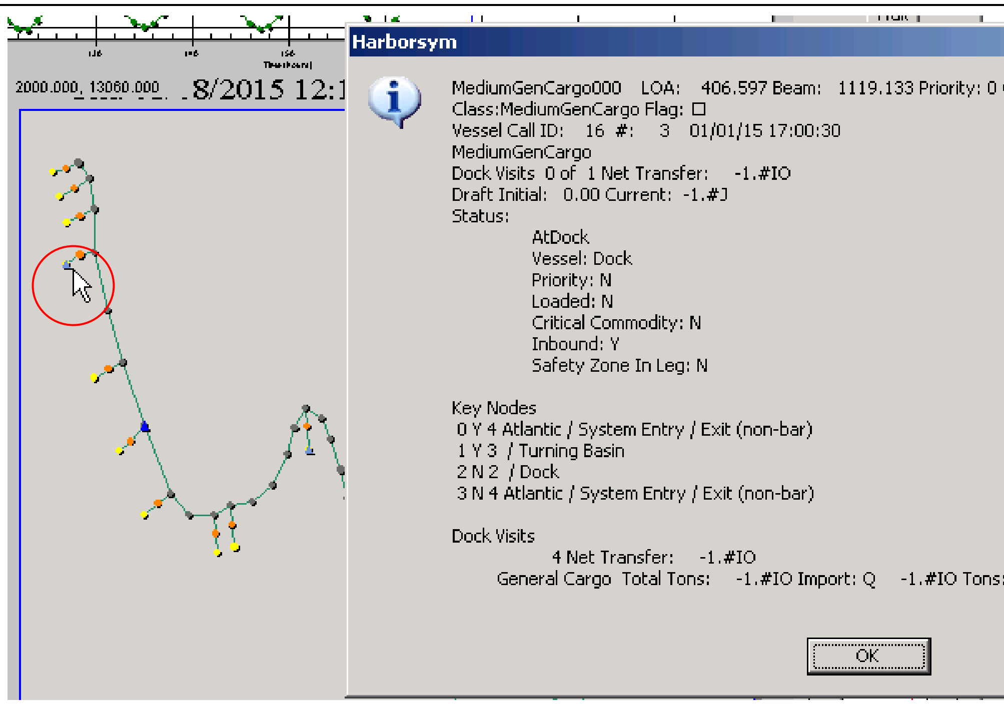


Figure 99: Vessel Query

The simulation processing speed can be accelerated by turning off the within simulation animation. To do so, select the "Resume" option and X from the radio buttons. The link-node network will disappear and HarborSym will continue to process the simulation without visualization. A window will appear informing the user when the simulation is complete. The simulation visualization can be re-started by again hitting the "Step" button.

8.4 Viewing Simulation Output Results

Project alternatives are analyzed by comparing the output of simulations. Within HarborSym the user can obtain the output of simulations in reports or graphs. Additional, more detailed external reports are also stored separately in the same folder as the project input file. These detailed reports are described in detail in Appendix C and should be reviewed for a thorough understanding of system behavior. The reports available through the HarborSym user interface, described in the following subsections, provide summary statistics and present an overview of the simulation results.

The output reports available within HarborSym are accessed through the Output Pillar on the toolbar. The output reports available are the Project Comparison Report, the Single Scenario Report, the Reach Rule Violations Report, the Transit Rules Report, the Vessel Class Characteristics Report, and the Commodity Info Report. The reports are accessed by clicking on Output and then clicking on Reports on the menu that appears. Choosing any of the reports reveals a dialogue box for selection of scenarios or projects, depending upon the report.

8.4.1 Project Comparison Report

The Project Comparison Report compares two or more projects using the same scenario. The Average Vessel Time in System (Harbor) and Average Vessel Cost are compared. The user must choose the Base Project (e.g., existing or without-project condition) against which all other selected projects are compared. Once the Base Project is chosen, the user can select as many projects as are available for comparison. To view the Project Comparison Report, proceed as follows:

1. From the menu, click on the "Output" pillar and select "Project Comparison." A dialogue box titled "Report Scenario Comparison" will appear.

2. Select the scenario and the base project from the first pop-up menu. Select the comparison project by checking the box in the selection below. An example of a Scenario Comparison Report is shown in Figure 100. It provides a date stamp for the run and the scenario name. Simulation results are shown in the bottom portion of the report.

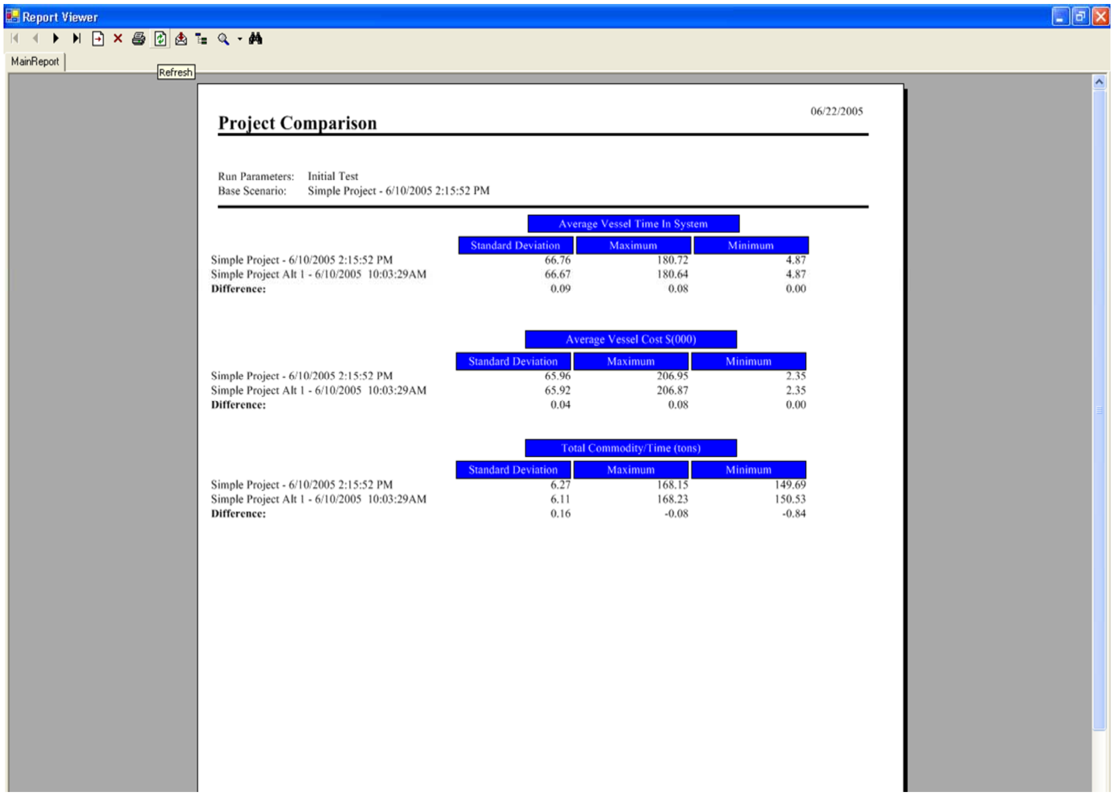


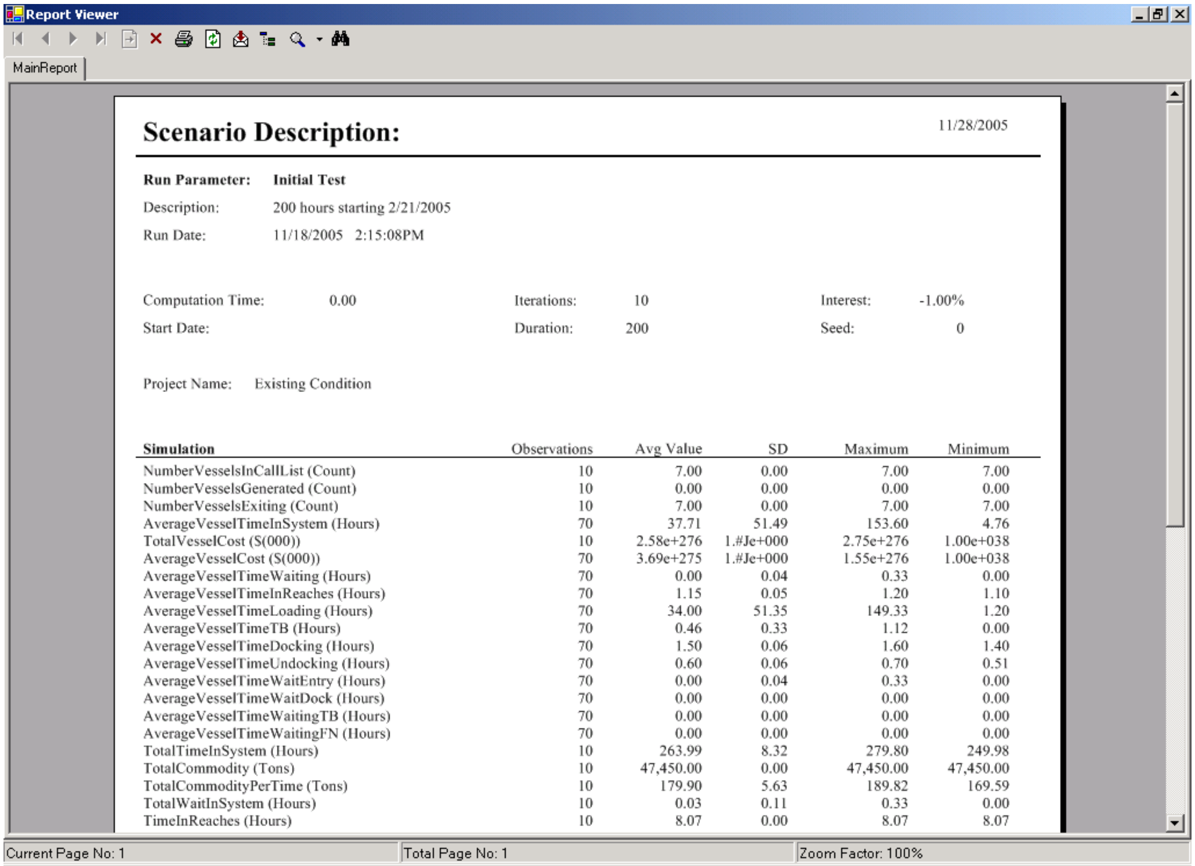
Figure 100: Example Scenario Comparison Report

8.4.2 Single Scenario Report

The Single Scenario Report provides detailed data on a single simulation of a single scenario and single project. The results for all iterations of the simulation are averaged, and the minimum, maximum, and standard deviation between the results of iterations are listed.

1. From the menu, click on the “Output” pillar and select “Single Scenario.” A dialog box titled “Report Builder” with a menu of scenarios will appear.

2. Select the appropriate scenario. Each scenario / project simulation run is listed in chronological order. An example of a Single Scenario Report is shown in Figure 101.



Report Viewer

MainReport

Scenario Description: 11/28/2005

Run Parameter: **Initial Test**

Description: 200 hours starting 2/21/2005

Run Date: 11/18/2005 2:15:08PM

Computation Time: 0.00 Iterations: 10 Interest: -1.00%

Start Date: Duration: 200 Seed: 0

Project Name: Existing Condition

Simulation	Observations	Avg Value	SD	Maximum	Minimum
NumberVesselsInCallList (Count)	10	7.00	0.00	7.00	7.00
NumberVesselsGenerated (Count)	10	0.00	0.00	0.00	0.00
NumberVesselsExiting (Count)	10	7.00	0.00	7.00	7.00
AverageVesselTimeInSystem (Hours)	70	37.71	51.49	153.60	4.76
TotalVesselCost (S(000))	10	2.58e+276	1.#Je+000	2.75e+276	1.00e+038
AverageVesselCost (S(000))	70	3.69e+275	1.#Je+000	1.55e+276	1.00e+038
AverageVesselTimeWaiting (Hours)	70	0.00	0.04	0.33	0.00
AverageVesselTimeInReaches (Hours)	70	1.15	0.05	1.20	1.10
AverageVesselTimeLoading (Hours)	70	34.00	51.35	149.33	1.20
AverageVesselTimeTB (Hours)	70	0.46	0.33	1.12	0.00
AverageVesselTimeDocking (Hours)	70	1.50	0.06	1.60	1.40
AverageVesselTimeUndocking (Hours)	70	0.60	0.06	0.70	0.51
AverageVesselTimeWaitEntry (Hours)	70	0.00	0.04	0.33	0.00
AverageVesselTimeWaitDock (Hours)	70	0.00	0.00	0.00	0.00
AverageVesselTimeWaitingTB (Hours)	70	0.00	0.00	0.00	0.00
AverageVesselTimeWaitingFN (Hours)	70	0.00	0.00	0.00	0.00
TotalTimeInSystem (Hours)	10	263.99	8.32	279.80	249.98
TotalCommodity (Tons)	10	47,450.00	0.00	47,450.00	47,450.00
TotalCommodityPerTime (Tons)	10	179.90	5.63	189.82	169.59
TotalWaitInSystem (Hours)	10	0.03	0.11	0.33	0.00
TimeInReaches (Hours)	10	8.07	0.00	8.07	8.07

Current Page No: 1 Total Page No: 1 Zoom Factor: 100%

Figure 101: Single Scenario Report

8.4.3 Reach Rule Violations Report

The Reach Rule Violations Report provides detailed information on the vessel traffic rules that resulted in wait and retries during a simulation. During HarborSym simulations, the rules are not actually violated. Instead of violating a rule, the moving vessel waits at the entrance to a leg until the conflict passes. After the specified time period the moving vessel attempts to move again in a "retry."

1. From the menu, click on the "Output" pillar and select "Reach Rule Violations." A dialog box titled "Report Builder" with a menu of projects will appear.

2. Select the appropriate scenario/ project combination.

3. From the menu, click on the "Output" pillar and select "Reach Rule Violations." A dialog box titled "Report Builder" with a menu of projects will appear.

4. Select the appropriate scenario/ project combination.

The Transit Rules Report provides detailed data on the rules implemented during a simulation. A report is available for each project simulated.

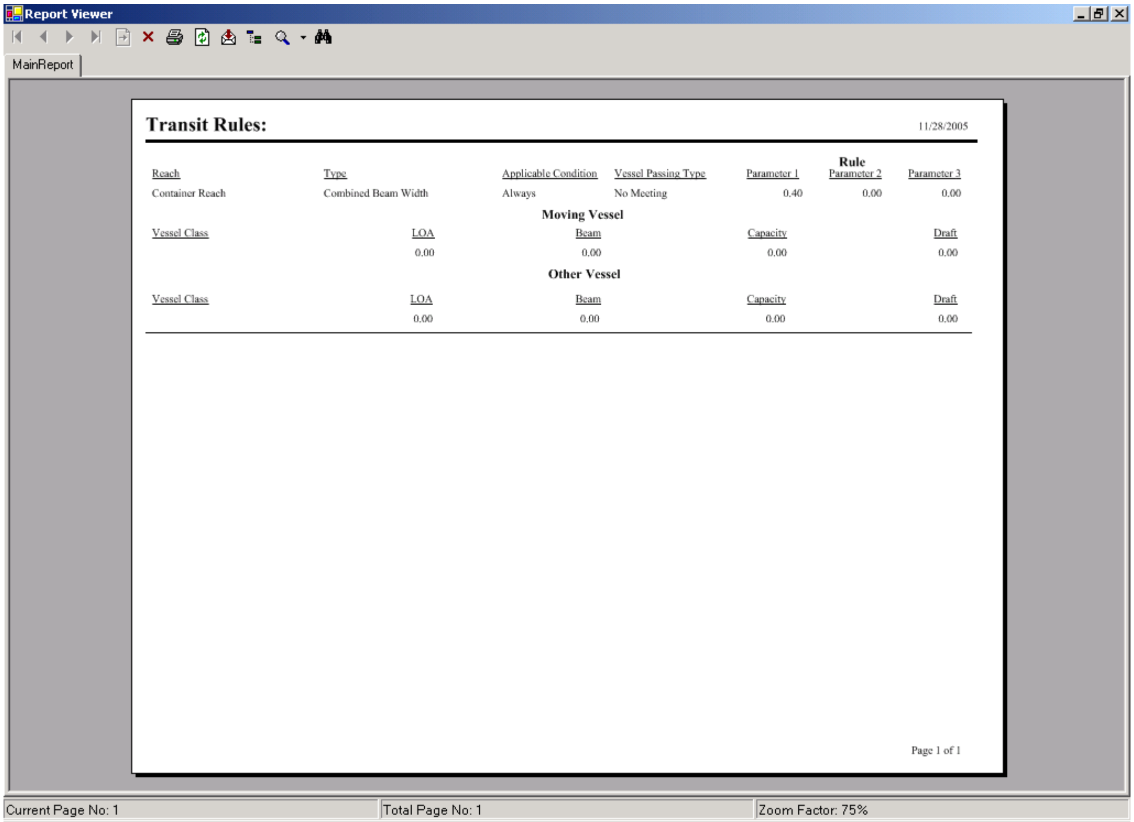


Figure 102: Transit Rules Report

1. From the menu, click on the "Output" pillar and select "Transit Rules." A dialog box titled "Choose Project for Report" with a menu of projects will appear.

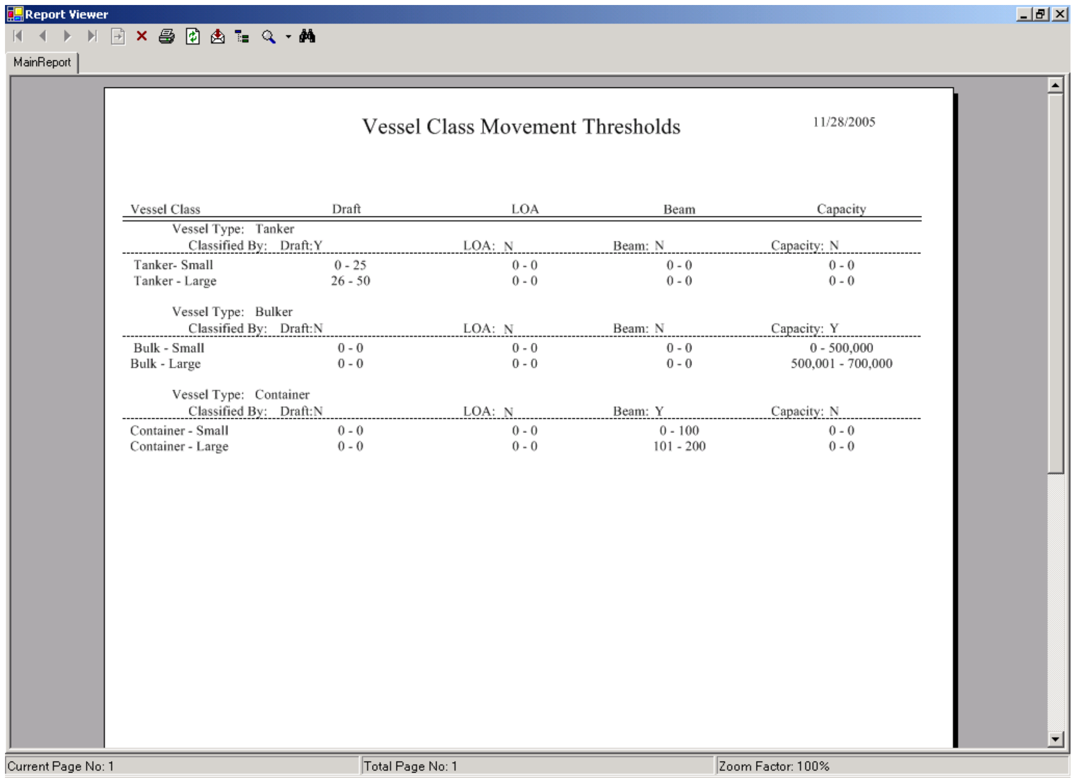
2. Select the appropriate project. An example of a Transit Rules Report is shown in Figure 102.

8.4.4 Vessel Class Characteristics Report

The Vessel Class Movement Thresholds Report provides detailed data on the measurement thresholds used to define vessel classes.

1. From the menu, click on the "Output" pillar and select "Vessel Class Movement Thresholds." An input box titled "Choose Projects for Report" with a menu of projects will appear.

2. Select the appropriate project. An example of a Vessel Class Movement Threshold Report is shown in Figure 103.



Vessel Class Movement Thresholds 11/28/2005

Vessel Class	Draft	LOA	Beam	Capacity
Vessel Type: Tanker				
Classified By:	Draft:Y	LOA: N	Beam: N	Capacity: N
Tanker- Small	0 - 25	0 - 0	0 - 0	0 - 0
Tanker - Large	26 - 50	0 - 0	0 - 0	0 - 0
Vessel Type: Bulker				
Classified By:	Draft:N	LOA: N	Beam: N	Capacity: Y
Bulk - Small	0 - 0	0 - 0	0 - 0	0 - 500,000
Bulk - Large	0 - 0	0 - 0	0 - 0	500,001 - 700,000
Vessel Type: Container				
Classified By:	Draft:N	LOA: N	Beam: Y	Capacity: N
Container - Small	0 - 0	0 - 0	0 - 100	0 - 0
Container - Large	0 - 0	0 - 0	101 - 200	0 - 0

Figure 103: Vessel Class Movement Threshold Report

8.4.5 Commodity Info Report

The Commodity Info Report provides detailed data on the units of measure and tons per unit of commodity categories.

1. From the menu, click on the “Output” pillar and select “Commodity Info.” An input box titled “Choose Project for Report” with a menu of projects will appear.

2. Select the appropriate project.

8.4.6 Output Graphs

HarborSym generates several outputs that display the simulation results in graphical form. These outputs are accessed through the Graphs option of the Output pillar, as shown in Figure 104.

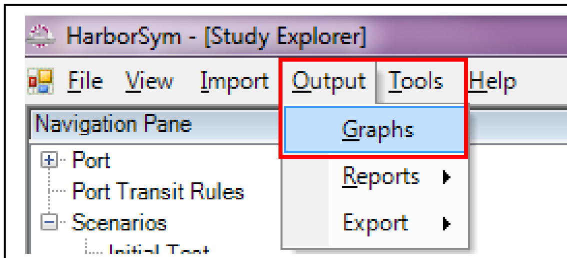


Figure 104: Graphical Outputs

Six graphs are available including:

Time in System	Vessel Time
Full Time Statistics	Rule Count by Type
Transportation Cost - Time	Rule Count by Reach

For all graphs, the user has the option to save or print the image. The Vessel Time graph is displayed in Figure 105. This graph plots the average vessel time in system for each iteration as well as a long run moving average over all iterations. This information can help the user determine if sufficient iterations have been processed to reach stability in outputs. Note that in order for the Vessel Time graph to display the correct average vessel time, the user must select the 'Iteration.csv' output option when running the simulation.

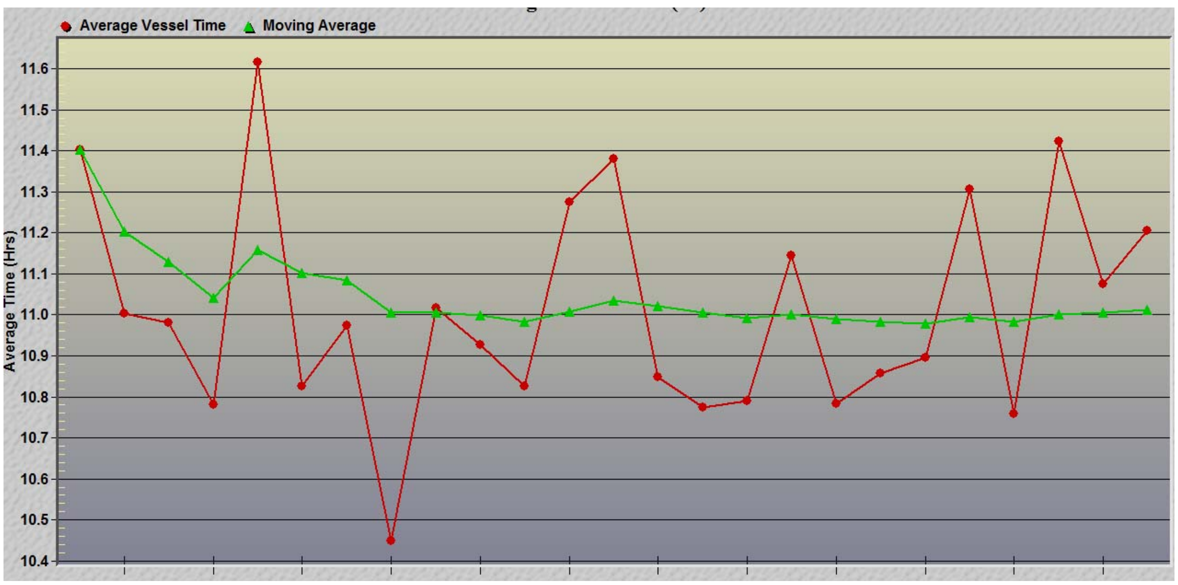


Figure 105: Vessel Time Graph

8.4.7 Output Files

Extensive data about simulations is available in output files. These files are obtained in Windows® Explorer. Appendix C contains detailed descriptions of the output files.

Section 9
Understanding HarborSym Output

HarborSym estimates vessel transit times based upon the harbor conditions defined by the project and simulation conditions established in the scenario. Simulation output includes the average time per vessel call and total time for all vessel calls at each phase of a harbor visit. The time spent by vessels in a harbor consists of the time transiting reaches and turning basins, the time waiting to prevent a rule violation, and the time loading and unloading commodities at docks. Vessels can wait outside the harbor at an entrance, in anchorages and at docks. The average and total time spent waiting at each of these locations by vessel class should be reviewed to determine how traffic is flowing through the harbor in the model.

HarborSym simulates vessel traffic based on individual vessel movement events and determines whether a vessel can proceed through a leg based upon the user defined vessel traffic rules. Detailed output files are produced to tabulate reach rule trigger. These internal and external reports can be used to determine the reaches in which vessel traffic is constrained and the vessel traffic rules that result in delays.

The following sections outline the type of data elements captured in the HarborSym outputs. Additional details on specific reports are provided in Appendix C.

9.1 Vessel Time in System and Total Vessel Cost

Vessel time in system is estimated based upon simulations of vessel traffic through the harbor. Total vessel cost is the cost of operating vessels in the harbor, which is estimated by multiplying the vessel operating cost for each vessel by the time in system for each vessel. The sum of vessel time spent transiting, turning, docking, loading, and waiting equals the time in system. Vessel traffic rules impact transit times because potential rule violations result in waiting time.

9.2 Reach Rule Violations

Vessel traffic rule violations do not occur during HarborSym simulations because vessels wait until conflicts clear and they can proceed. In HarborSym reports, these waiting events are listed as rule violations. Each unsuccessful retry is counted as an additional rule violation or trigger. By reviewing reach rule violations the user can determine where transit rules are resulting in vessels waiting.

9.3 Vessels Exiting, Vessels Remaining, and Deleted Vessels

Vessels that enter the harbor during a simulation will either exit the harbor, remain in the harbor when the simulation ends, or be deleted during the simulation. The number of vessels exiting the harbor may be less than the number of vessels in the vessel call list because some vessels will be at docks or transiting reaches when the simulation ends. Various output files document the number of vessels remaining in the system at the end of the simulation as well as all deleted vessels (output reports are described in detail in Appendix C). Remaining vessels may not indicate problems with the simulation or data, as they simply represent calls that did not complete processing within the allocated simulation duration. Special behavior is built into HarborSym to ensure priority vessels that

remain in the system at the conclusion of the simulation are visible to all vessels in the full call list run (additional discussion of this capability is available in Section 3.2.5).

The user should consider that the number of vessels exiting the harbor may be reduced because some vessel calls are deleted when vessels become “stuck” at a node in the harbor. The time in system for these deleted vessel calls are not included in output reports. When evaluating and comparing projects, the number of deleted vessel calls should be considered. The user should try to minimize deleted vessel calls by increasing the number of retries allowed during simulation or adjusting vessel call information to accurately reflect system conditions. Deleted vessel calls will impact the amount of commodity loaded and unloaded during a simulation and may result in under or overestimates of with-project benefits.

9.4 Vessel Time Waiting

Vessel time waiting is the time vessels spend waiting to prevent a rule violation. Vessels can wait either at the entrance, at a dock, or at an anchorage. Vessel time waiting is the primary variable changed by harbor improvements.

9.5 Vessel Cost

Vessel cost is the product of vessel time in system and vessel operating cost. HarborSym calculates vessel operating cost. The time spent in the system consists of time spent at the docks and the time spent transiting to and from the docks. ”In port” costs are used for the time vessels are at a dock and “at sea” costs are used for the time a vessel spends transiting through the harbor. A detailed description of in port and at sea cost application is included in Section 3.2.5. Details on how at-sea costs are applied to the subject port are provided in Section 3.3.1.

Section 10

HarborSym Animation Module (HSAM)

In recent years, the importance of model transparency and validation has increased as stakeholders and decision-makers require greater confidence in analytical tools and a better understanding of model inputs and outputs. It must be clear what the models do, and precisely how they do it. To this end, graphical visualization of model data and behavior has been integrated as a fundamental aspect of model design and usage. Visualization techniques have evolved over time, as new insights into what would be worthwhile are learned by usage, and as new users with different perspectives and desires apply the various navigation analysis tools.

The HarborSym Animation Module (HSAM) was developed to convey results of a HarborSym simulation, including traffic patterns. The animation package portrays information in a fashion and environment familiar to an audience ranging from subject matter experts with deep knowledge of the processes involved and the details of navigation issues, through high-level officials with extreme constraints on available time and strong needs for information condensation. HSAM is a simple, elegant, versatile, and cost effective solution for the analysis and presentation of vessel traffic movement data for various purposes.

A key design feature of HSAM is the ability to control the appearance and content of the animation from the parent simulation model, HarborSym, without the need to recompile any portion of the system or the need for a multi-media production engineer. HSAM is configured from within HarborSym. The user first selects a graphic representing the geography of the harbor being simulated. This can be a navigation chart or an artistic rendering. This will be the surface on which system animates movements of the vessels. Intrinsic to the development of the HarborSym simulation is the specification of the network of waypoints, docks, reaches, and turning basins. The network layout and vessel call lists created in HarborSym are utilized in HSAM for visualization.

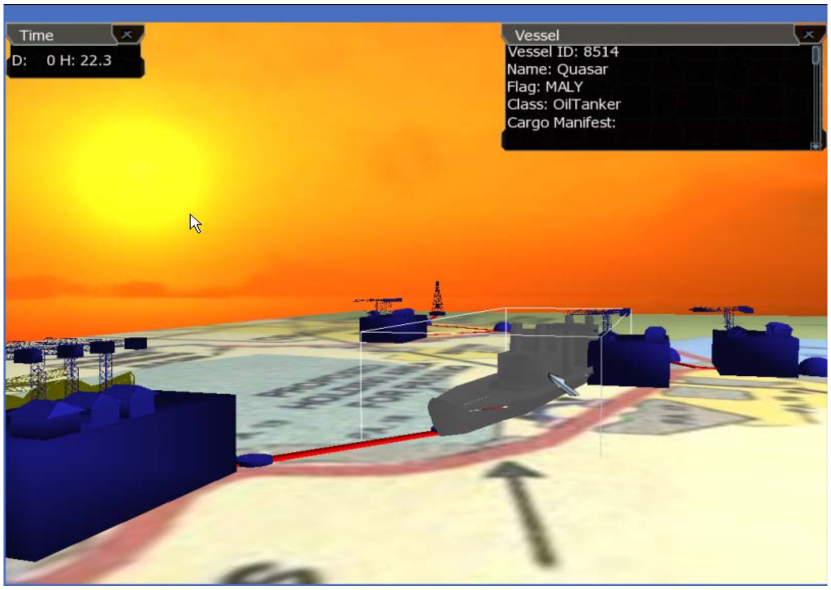


Figure 106: HSAM Visualization

HSAM allows the user to specify a visually distinctive 3D model, or avatar, for each class of vessel. The texture applied to the avatar is also user selectable. Thoughtful selection of avatars and textures can have a strong impact on what is being demonstrated by the

resulting animation. Simple coloration changes can bring the movement patterns of select classes of vessels sharply into focus. The textures used to provide both the sky and horizon, are user selectable for both daytime and nighttime. HSAM allows distinctive day/night environment textures to emphasize alternate rule schemes. HSAM is directed to make vessel movements and environmental alterations through a time sequenced queue of event commands. This command queue puts the simulated vessel fleet into motion.

The HSAM animation framework consists of a series of related objects working in concert to respond to a time ordered series of events to provide an animated depiction of the simulation data streams. The foundational objects in the HSAM framework are vessel, navigation node, and navigation reaches. These objects represent physical locations, the routes between those locations, and the vessels that move along those routes.

10.1 Vessel Objects

The vessel object, which represents the distinct vessels that will appear in the animation, has characteristic properties including a unique identifier, name of vessel, flag of registry, draft, beam, physical dimensions, a cargo manifest, position, orientation, status, visibility, an avatar which is the physical representation of the object in the simulated environment, the vessel's class and sub-class identifiers, and a texture or simple color to be applied to the vessel avatar. A sampling of vessel avatars developed for HSAM is shown in Figure 107.

Figure 107: Sample HSAM Vessel Avatars

The vessel object retains a time sequence ordered queue of commands that pertain to itself and its cargo manifest. Vessel commands are directives to alter one or more of the vessel's properties either at a specific point in time or, in the case of a movement command, over a span of time. Properties that can be altered through a vessel command event are position, status, visibility, orientation (independent of default movement orientation), and avatar texture. Vessels can also be issued cargo manifest alteration commands. These commands take the form of a commodity code, a unit of measure, and a transaction quantity. At the indicated trigger time, the vessel's cargo manifest is adjusted in accordance with the parameters of the command. Finally, as an optimization point, there is a "destruct" command that is issued to an instance of a vessel when it is no longer significant in the simulation, i.e., the calling vessel leaves the harbor. The destruction of the vessel immediately frees system resources and is used to improve average frame rate capabilities of HSAM.

10.2 Navigation Node and Navigation Reach Objects

The HSAM animation framework maintains a hash table collection of those objects forming the navigation network – navigation nodes and navigation reaches. The navigation node object encapsulates a location in the simulated world that vessels may depart from, arrive at, or pass

through. The navigation node object has properties encompassing a unique identifier, a name, status, a cargo throughput list, position, orientation, an avatar, a texture, and a category or type indicator designating the node object as dock, way point, entry bar, or a turning basin. The category types are user defined during animation configuration as are the default avatars for each defined category as well as specific node avatar and texture overrides. The navigation node object retains a collection of commodity transaction volumes capable of tracking summary utilization in terms of cargo throughput. In addition to executing commands to allow the texture of the node, the status, and the visibility of the node to be modified, the node object processes commands to maintain the summary cargo lists. These commands allow resetting or clearing of the list and pass-through transactions indicating the cargo commodity type, the unit of measure and the quantity passing through the node. The pass-through transactions also indicate if the cargo was loaded or unloaded and the lists of loaded and unloaded cargo are maintained separately so as to allow the analyst to visualize trends or even anomalies in commodity flow.

The Navigation Reach object is a far simpler construct. A navigation reach is defined as a directed line connecting exactly two navigation nodes. The properties for reaches include a reach class identifier, a specific reach instance avatar, a texture or simple color for that avatar, and a status. The commands that can be issued to a reach object allow the texture of the reach, the status, and the visibility of the entire reach to be modified. Much like the vessel objects, both the node and reach objects maintain a time sequenced queue of commands pertaining to their specific instances. The nature of the commands available to the objects in the navigation network is more restrictive than those for the vessels as the arrangement of the network must be fixed prior to the appearance of the first vessel in the animation. Once time has begun to pass, the basic appearance of the network is no longer malleable. The command set and properties of the navigation node and navigation reach objects form the navigation network over which vessels transit in the animation and is well suited to the visual depiction of the changing status, conditions, and cargo movement patterns in deep-draft harbors.

10.3 Download and Install HSAM

HSAM is available for download from the HarborSym website, as shown in Figure 108, (http://www.pmcl.com/harborsym/). Users must download and install HSAM separately from HarborSym. To do so, navigate to the "Download" page from the menu bar on the HarborSym home page. HSAM is available for download in the "Animation Module" section.

Figure 108: HarborSym Website Download

10.3.1 Internet Download Installation

- Download the installation file to a temporary directory (Example, C:\Temp).
- Click the start button on the Taskbar.

- Click Run.
- Type the path to the downloaded file (Example, C:\Temp\Setup.exe).
- Click the "OK" button.
- Follow instructions to complete setup.

10.3.2 Uninstall

- Click the Start button on the Taskbar.
- Click Settings.
- Click Control Panel.
- Double-click Select Add/Remove Programs.
- Select "HSAM".
- Click the Add/Remove button.

10.4 HarborSym Output for HSAM Animation

Generating HSAM visualization requires simulation output and configuration settings from HarborSym. A vessel movement file (.vmf) must be produced during a scenario processing of HarborSym. This file is created through the Output Control Settings window, which is launched from the scenario editor screen by pressing the "File Settings" button, as shown in Figure 109. (Section 6.12 contains details on completing the scenario editor form and processing a simulation.) Within the Output Control Settings window, the Output to Data Files for the Vessel Movement (.vmf) selection must be activated, as shown in Figure 110.

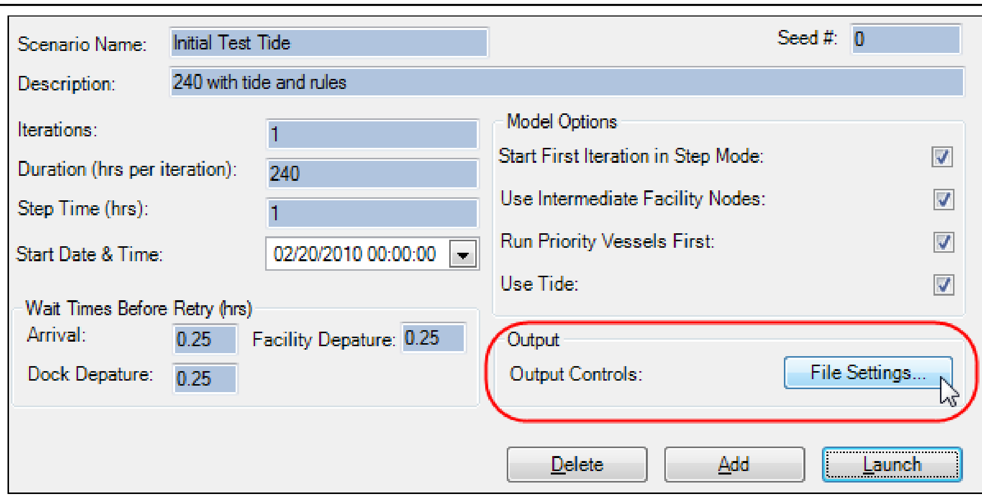


Figure 109: Launch File Settings Configuration

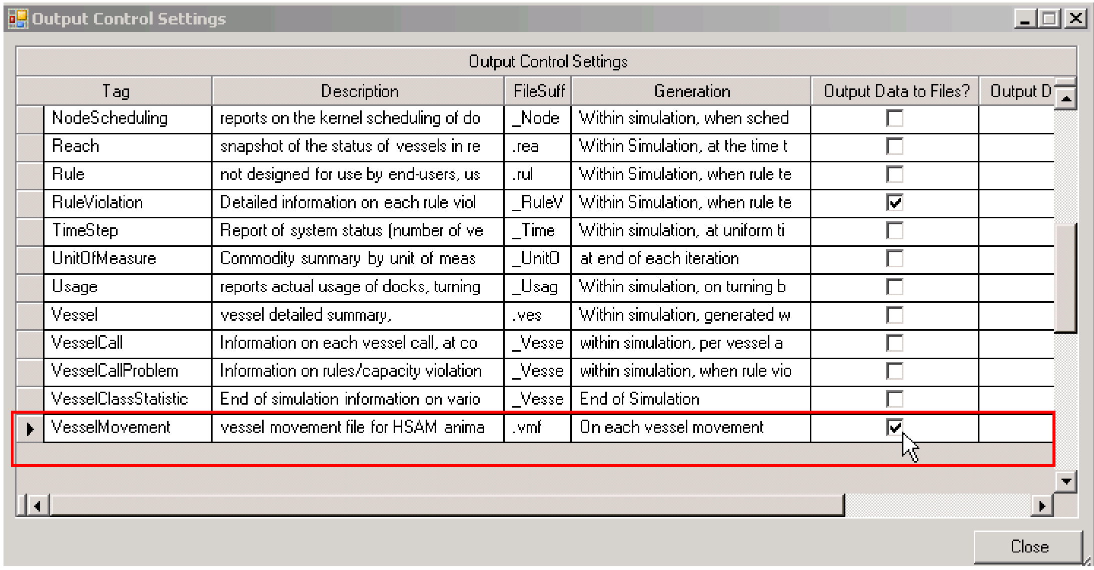


Figure 110: File Settings Configuration

After activating the vessel movement file option, HarborSym must process a complete simulation. There are no additional parameters that must be set special for a HSAM run; process the simulation as desired.

10.5 HSAM Options Window

When the simulation completes, right click on the project name in the Navigation Pane and select Output HSAM Information, as shown in Figure 111. This will launch the HSAM Options window. HSAM includes options for selecting the simulation run, the iteration, the location of the HSAM installation and display options. These parameters are established through the HSAM Options window.

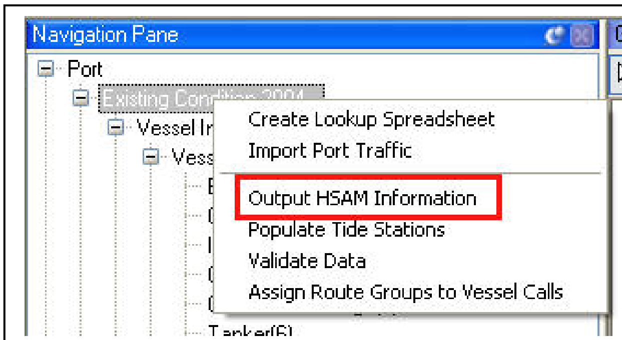


Figure 111: Output HSAM Information

Select a simulation to review in HSAM from the Available Simulation Runs pull down menu. This will list all simulations with usable Vessel Movement files for HSAM animation.

Through this window the animation display options can be selected. These include options to select the graphic and color utilized for each vessel type, the color and graphic utilized for nodes and the reach color.

10.6 HSAM Operating Controls

Once a HSAM simulation has launched using the above steps, the user can control the visualization appearance using the controls listed in Figure 112 and Table 8.

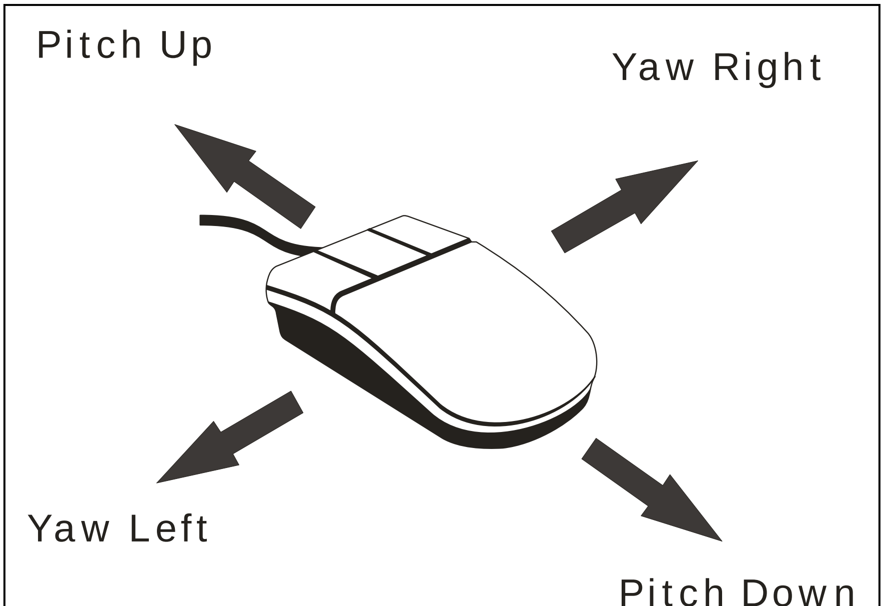


Figure 112: HSAM Operations

Table 8: HSAM Operational Key Strokes

Key	Action
A	Accelerate on the X axis (move right)
D	Decelerate on the X axis (move left)
S	Accelerate on the Z axis (move forward)
W	Decelerate on the Z axis (move backward)
Left Arrow	Yaw left (spin left)
Right Arrow	Yaw right (spin right)
Up Arrow	Pitch up (nose up)
Down Arrow	Pitch down (nose down)
Page-up	Increase time speed
Page-down	Decrease time speed
Right Shift	Decrease vessel size (all)
Left Shift	Increase vessel size (all)
P	Toggle interrogation mode (query database by picking vessel) *Time is stopped when this mode is entered. Use the Page-Up key to start time once you have exited this mode. Time cannot be adjusted while in Interrogate mode.*
ESC	Exit animation

Appendix A

Importing Data into HarborSym

Templates can be used to import data into HarborSym and reduce the amount of manual data entry effort required of the user. The templates use Microsoft Excel spreadsheets to format data consistently so large amounts of data can be compiled and analyzed using Excel's features. There are three steps to using templates in HarborSym, creating the spreadsheet template within the study, completing the spreadsheet template, and importing the spreadsheet. Templates are created and then imported through the HarborSym Import menu.

A.1 Importing the Vessel Call List

Port traffic is imported through the Lookup Spreadsheet. The spreadsheet is one of six worksheets in the Port Traffic Import Template, which is an Excel workbook. The workbook contains separate tabs titled, Field_Descriptions, Commodity, Dock, Vessels, Calls, and Flags, as described below. Section 6.6 provides details on the process for creating a lookup spreadsheet and importing data into HarborSym.

- The "Commodity" worksheet converts commodity category descriptions to commodity category numbers and can be populated by HarborSym during the "Create Lookup Spreadsheet" routine.
- The "Dock" worksheet converts dock descriptions to dock numbers and can be populated by HarborSym during the "Create Lookup Spreadsheet" routine.
- The "Vessel_Types" worksheet converts vessel type descriptions to vessel type numbers and can be populated by HarborSym during the "Create Lookup Spreadsheet" routine.
- The "Vessel_Classes" worksheet lists the vessel class names and number. This worksheet can be linked to the Calls tab through the VLOOKUP function.
- The "Route Groups" worksheet lists the route group description and number specified in HarborSym. This information can be used to populate the Route_Group_Name and Route_Group_Number fields in the Calls worksheet.
- The "Flags" worksheet lists the nation code for each nation. American flagged vessels use the code "AMER" and have domestic operating costs applied to their transit times. All other flags, including the generic "Z_Foreign", are associated with foreign operating costs.
- The "Calls" worksheet contains the information that is imported into HarborSym to populate the port traffic data entry grids. This worksheet can be linked to the Commodity, Dock, and Vessel tabs through the VLOOKUP function. This function obtains vessel class numbers, dock numbers and commodity category numbers. Table 9: Import Spreadsheet Field Definitions provides a description of each field in the Calls worksheet.

  The Field_Descriptions tab defines all the columns in the "Calls" worksheet. The field definitions are outlined in Table 9.

Table 9: Import Spreadsheet Field Definitions

Field	Description
Movement_Number	This number must be unique for each vessel trip. The movement number should be repeated for trips with multiple dock visits, multiple commodity types, and import and export movements.
Arrival_Date	Date the vessel arrives at the port entrance
Arrival_Time	Time the vessel arrives at the port entrance
Vessel_Name	Name of the vessel
Entry_Point	Node in HarborSym network where the vessel will enter the port
Exit_Point	Node in HarborSym network where the vessel will exit the port
Arrival_Draft	Vessel draft upon arrival at the entrance point, expressed in feet
Import/Export	Designation of whether the cargo listed is intended for import or export at the dock, indicated by either I or E. Multiple entries in the import spreadsheet, with the same movement number, are necessary for movements with both import and export cargo.
Dock_Name	Name of node in HarborSym (dock node) where the vessel will stop during this portion of the movement. If the vessel will visit more than one dock, multiple entries, with the same movement number, must be entered into the import spreadsheet.
Dock_Number	The HarborSym auto populated dock number corresponding to the dock name.
Dock_Order	The sequence of dock visit during the vessel trip. If only one dock is visited during the movement, enter 1.
Commodity_Name	The name of the commodity moved on the vessel, corresponding to the entry in the Import/Export field. Movements carrying multiple commodities will require multiple entries in the import spreadsheet with the same movement number.
Commodity_Number	The HarborSym auto populated commodity number corresponding to the commodity name.
Commodity_Units	Quantity of commodity transferred during this portion of the movement. The entry should reflect only quantity exchanged in the direction indicated in the Import/Export field (i.e., only the amount either imported or exported) at the specific dock referenced in the Dock_Number field. The unit of measure (i.e., tons, containers, vehicles, passengers) must correspond with the unit of measure provided in the HarborSym interface for this type of commodity.
Vessel_Type_Name	The name of the vessel type classification for this vessel, corresponding to one vessel type entered into the HarborSym interface.
Vessel_Type_Number	The HarborSym auto populated vessel type number corresponding to the vessel type name.
Unique_Vessel_Identifier	A numerical value unique for each individual vessel in the call list. If a specific vessel has multiple calls in the call list, each should reflect the same Unique Vessel Identifier.
NRT	Net registered tons (optional)
GRT	Gross registered tons (optional)
DWT	Deadweight tons (optional)
Capacity	Numeric value reflective of maximum capacity of the vessel; this should correspond with the commodity unit of measure carried on the vessel.
LOA	Length overall (in feet, consistent with the units used to define reaches in HarborSym)
Beam	Width of the vessel (in feet, consistent with the units used to define reaches in HarborSym)
Draft	Maximum sailing draft of the vessel (in feet, consistent with the units used to define reaches in HarborSym)
Flag	Country of vessel flagging

Field	Description
TPI_Factor	Tons per inch immersion factor, used to calculate sailing draft after commodities are exchanged at the dock
Route_Group_Name	The name of the route group for the vessel call, leave blank if unknown
Route_Group_Number	The number of the route group corresponding with the route group name for the vessel call, leave blank if unknown
Vessel_Class_Name	The vessel class name, leave blank if unknown
Vessel_Class_Number	The vessel class number corresponding with the vessel class name, leave blank if unknown
ETTC	Estimate of total trip cargo, defined as the cargo on board the ship at arrival plus the cargo on board the ship at departure in tons. Used to allocated all or a portion of the at-sea costs to the subject port. See Section 3.3.1 for details.

A.2 Importing Vessel Speed in Reach

When creating the Vessel Speed in Reach template, HarborSym will create an Excel workbook with a single worksheet containing a matrix of vessel classes and reaches for a project. The user must complete the matrix by entering the light and loaded speed (in nautical miles per hour) of a given vessel class for each reach. Once complete, the workbook can be imported into HarborSym. After the import, the data grid found under “Reaches”, tab “Speed in Reach”, will be completed.

A.3 Vessel Docking Time

When creating the Vessel Docking Time template, HarborSym will create an Excel workbook with a single worksheet containing a matrix of vessel classes and docks for a project. The user must complete the matrix by providing the minimum and maximum docking and undocking time for each vessel classification at each dock in hours. Once complete, the workbook can be imported into HarborSym. After the import, the data grid found under “Docks”, tab “Vessel Docking Time”, will be completed.

A.4 Vessel Turning Time

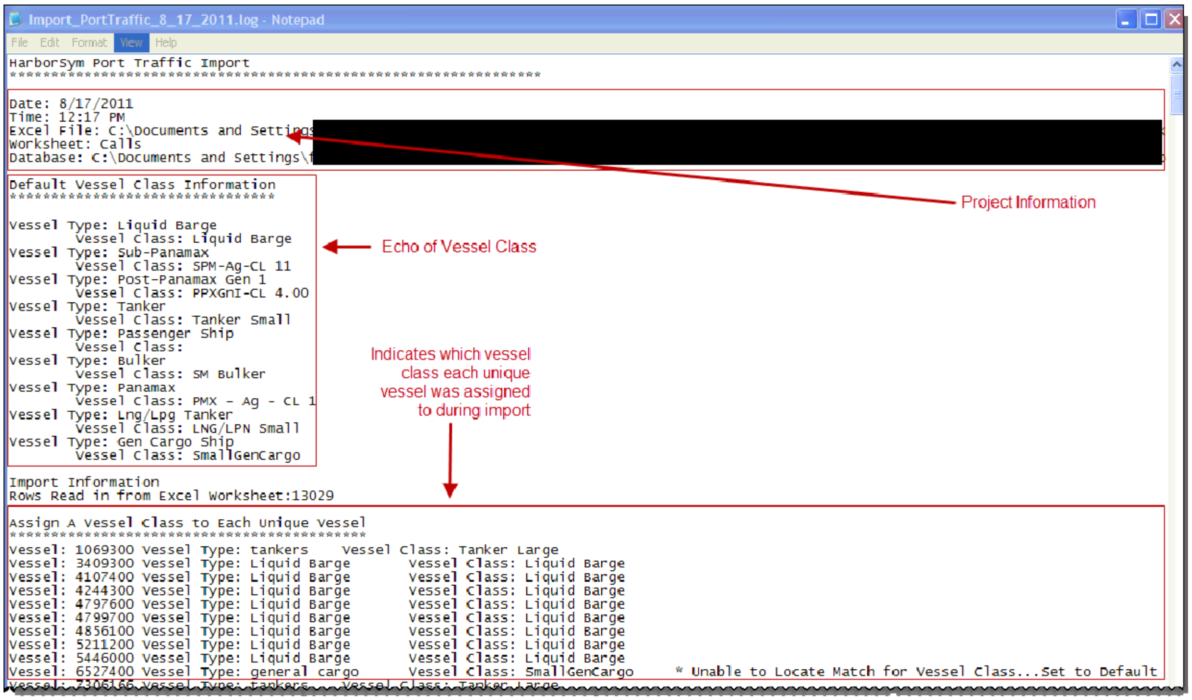
When creating the Vessel Turning Time template, HarborSym will create an Excel workbook with a single worksheet containing a matrix of vessel classes and turning basins for a project. The user must complete the matrix by providing the minimum, most likely, and maximum vessel turning time for each vessel class at each turning area. Once complete, the workbook can be imported into HarborSym. After the import, the data grid found under “Turning Basin”, tab “Vessel Turning Basin Time”, will be completed.

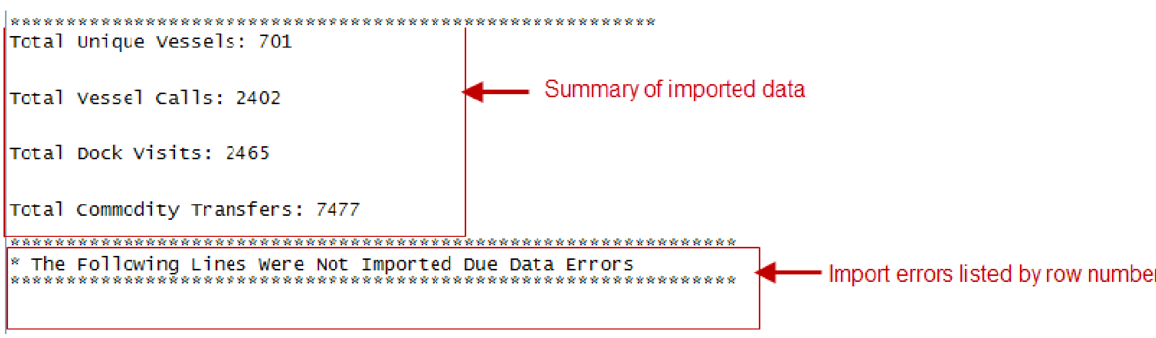
A.5 Commodity Transfer Rates

When creating the Commodity Transfer Rate template, HarborSym will create an Excel workbook with a single worksheet containing a matrix of vessel types, commodity categories, and docks for a project. The user must complete the matrix by providing the minimum, most likely, and maximum loading and unloading rate for each combination. Once complete, the workbook can be imported into HarborSym. After the import, the data grid found under “Docks”, tab “Commodity Transfer Rate”, will be completed.

A.6 Sample Import Error Log

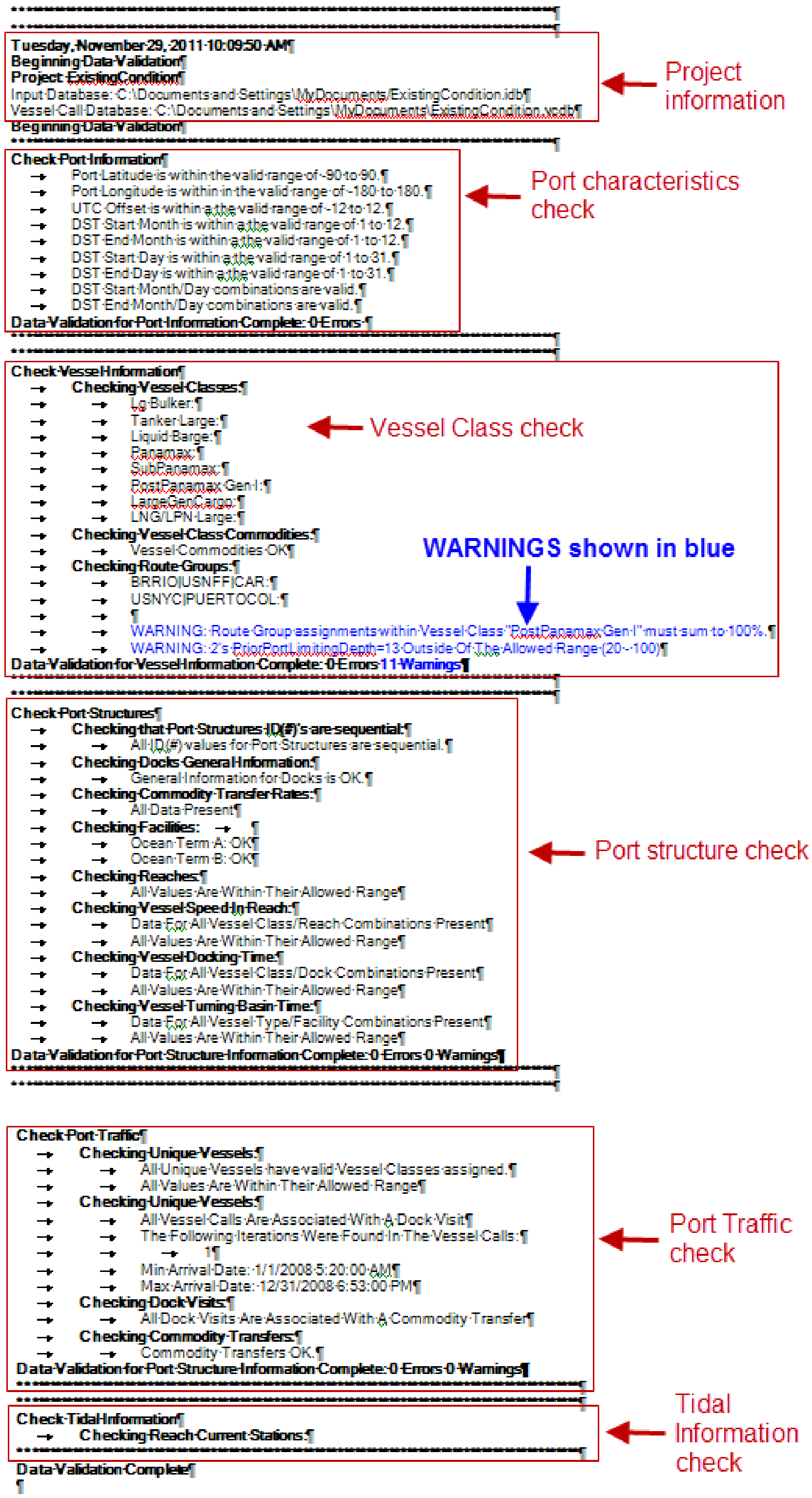
As described in Section 6.6.4, an import error log is created to document any problems HarborSym encountered during the vessel call list import. The following images provide an annotated sample import error log.





A.7 Sample Data Validation Report

As described in Section 5.7.5, HarborSym includes a data validation tool to evaluate the completeness and reasonableness of user provided data. A data validation report is generated following the routine to outline any identified problems. The following images provide an annotated sample data validation report.


Tuesday, November 29, 2011 10:09:50 AM
Beginning Data Validation
Project: ExistingCondition
Input Database: C:\Documents and Settings\MyDocuments/ExistingCondition.idb
Vessel Call Database: C:\Documents and Settings\MyDocuments\ExistingCondition.vcdb
Beginning Data Validation
Project information
Check Port Information
Port Latitude is within the valid range of -90 to 90.
Port Longitude is within in the valid range of -180 to 180.
UTC Offset is within a the valid range of -12 to 12.
DST Start Month is within a the valid range of 1 to 12.
DST End Month is within a the valid range of 1 to 12.
DST Start Day is within a the valid range of 1 to 31.
DST End Day is within a the valid range of 1 to 31.
DST Start Month/Day combinations are valid.
DST End Month/Day combinations are valid.
Data Validation for Port Information Complete: 0 Errors
Port characteristics check
Check Vessel Information
Checking Vessel Classes:
Lg Bulker:
Tanker Large:
Liquid Barge:
Panamax:
SubPanamax:
PostPanamax Gen I:
LargeGenCargo:
LNG/LPN Large:
Checking Vessel Class Commodities:
Vessel Commodities OK
Checking Route Groups:
BRRIOIUSNFFICAR:
USNYCIPUERTOCOL:
WARNING: Route Group assignments within Vessel Class "PostPanamax Gen I" must sum to 100%.
WARNING: 2's PriorPortLimitingDepth=13 Outside Of The Allowed Range (20 - 100)
Data Validation for Vessel Information Complete: 0 Errors 11 Warnings
Vessel Class check
WARNINGS shown in blue
Check Port Structures
Checking that Port Structures ID(#)'s are sequential:
All ID(#) values for Port Structures are sequential.
Checking Docks General Information:
General Information for Docks is OK.
Checking Commodity Transfer Rates:
All Data Present
Checking Facilities:
Ocean Term A: OK
Ocean Term B: OK
Checking Reaches:
All Values Are Within Their Allowed Range
Checking Vessel Speed In Reach:
Data For All Vessel Class/Reach Combinations Present
All Values Are Within Their Allowed Range
Checking Vessel Docking Time:
Data For All Vessel Class/Dock Combinations Present
All Values Are Within Their Allowed Range
Checking Vessel Turning Basin Time:
Data For All Vessel Type/Facility Combinations Present
All Values Are Within Their Allowed Range
Data Validation for Port Structure Information Complete: 0 Errors 0 Warnings
Port structure check
Check Port Traffic
Checking Unique Vessels:
All Unique Vessels have valid Vessel Classes assigned.
All Values Are Within Their Allowed Range
Checking Unique Vessels:
All Vessel Calls Are Associated With A Dock Visit
The Following Iterations Were Found In The Vessel Calls:
1
Min Arrival Date: 1/1/2008 5:20:00 AM
Max Arrival Date: 12/31/2008 6:53:00 PM
Checking Dock Visits:
All Dock Visits Are Associated With A Commodity Transfer
Checking Commodity Transfers:
Commodity Transfers OK.
Data Validation for Port Structure Information Complete: 0 Errors 0 Warnings
Port Traffic check
Check Tidal Information
Checking Reach Current Stations:
Data Validation Complete
Tidal Information check

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Appendix B

HarborSym Vessel Traffic Rules

B.1 Introduction

A large selection of vessel traffic rules are available to the HarborSym user to apply to the entire harbor or to particular reaches within the harbor. Multiple rules may be selected for any reach. Vessel traffic rules are for single vessels or for vessel encounters, and are based on harbor conditions and vessel parameters. Different rules require different data entry parameters, which are defined in Table 10. The “Wait Cause” field in Table 10 reflects the general causes for delay, as described in Section 3.2.9. Traffic rules that can be implemented are described in Table 11.

Vessel traffic rules regulating vessel encounters are defined by the user. For each reach during each time step the HarborSym model analyzes vessel encounters. Every vessel encounter is based upon the moving vessel and the other vessel. The other vessel is defined as the vessel that has already been approved to proceed through a reach. The scheduled entry and exit times of all such vessels are maintained by the simulation and known for each reach. The approach of the moving vessel to the reach is evaluated by the HarborSym model to determine if an encounter between the moving vessel and any of the other vessels that are scheduled to be in the reach at the same time as the moving vessel would result in a rule violation. If a vessel traffic rule would be violated by the moving vessel proceeding through the reach and encountering the other vessel, the model requires that the moving vessel wait at the entrance to the leg for a user-defined period of time. After that time, the moving vessel again attempts to enter the leg, and the rules are re-tested with the new times.

The columns in the Transit Rule Data Entry Grid are described below, starting from the left side of the grid. Some of the blocks have menus selections. The blocks for which data entry is mandatory are highlighted.

Desc: Checking this box prompts a description of the rule

Reach: The name of the reach is listed

Active: Checking this box activates the rule during the next simulation, if “Apply Transit Rules” is selected in the scenario definition.

Type: This column is used to select a rule from the menu of available rules. The titles of the vessel transit may not adequately describe the rules, but holding the cursor over the Type box in the Data Entry Grid will prompt a definition of the rule to appear on the screen. The description can also be recalled by pressing the description square () at the left of the rule row.

Application Condition: This column allows a selection of always/day/night in which the rules will apply.

Vessel Passing Type: Used to select passing/overtaking/ or either encounter with which to apply multiple vessel rules.

- No Meeting – no passing/no overtaking.

- No Overtaking – cannot pass when both vessels are going the same direction.
- No Passing – vessels cannot pass each other going opposite directions.

Rule Parameter 1 / Parameter 2 / Parameter 3: These columns are for the specific data input required for some rules. The type of data entry varies between rules and is defined by the rule definition table as specified in Table 11. If data entry in one of these block in required, the block is highlighted.

Moving Vessel Class / LOA / Beam / Capacity/ Draft: These columns allow the user to specify the moving vessels to which the vessel traffic rule applies. The moving vessel fitting the values defined in these blocks will wait before entering a reach depending upon the other vessel as specified in Table 12.

Other Vessel Class / LOA / Beam / Capacity/ Draft: These columns allow the user to specify the characteristics of the other vessels to which the vessel traffic rule applies. The other vessel must fit the values defined in these blocks for the rule test to be carried out, depending upon the definition of the rule and the moving vessel as specified in Table 12.

Table 10: Vessel Traffic Rules – Number and Title

Transit Rule Type No.	Transit RuleType Short Description	Wait Cause
0	No Rule	Not applicable
1	Vessel LOA or Beam or Capacity	Vessel Size Constraint
2	Combined Beam Width	Congestion
3	Combined Draft	Congestion
4	Capacity1: Capacity Limit V1 AND (Draft Limit OR Capacity Limit V2)	Congestion
5	Capacity2: Capacity Limit V1 AND (Draft Limit AND Capacity Limit V2)	Congestion
7	Capacity3: (Capacity AND Draft Limit V1) OR (Capacity AND Draft Limit V2)	Congestion
8	Critical Commodity Vessel	Critical Commodity
10	Maintain Safety Zone	Buffer Zone
11	Draft AND Combined Beam Width Limit	Congestion
13	Draft Limit V1 Protocol Vessel V2	Congestion
14	Any Vessel	Congestion
16	Vessel Class V1 Protocol Vessel V2	Congestion
17	Draft Plus Tide	Tide
18	Draft Limit	Vessel Size Constraint
19	Draft Range LOA Limit Current Limit	Tide
20	Draft Limit Current Limit	Tide
21	LOA Limit Current Limit	Tide
22	Directional Draft Limit Current Limit	Tide
24	Directional Draft Limit LOA Limit	Tide
25	Draft Plus Tide To Max Draft	Tide
26	Beam Reach Width Limit	Vessel Size Constraint
27	Draft Exceeds Depth Using Tide / Underkeel	Tide
28	Vessel Class Beam Limit	Vessel Size Constraint
29	Vessel Class LOA Limit	Vessel Size Constraint
30	Draft Limit V1 OR Draft Limit V2	Vessel Size Constraint
31	Safe Distance	Buffer Zone

Transit Rule Type No.	Transit Rule Type Description
1	Vessel LOA or Beam or Capacity; Single Vessel Rule. This is an OR rule applying to moving vessel only. A vessel cannot move if its LOA, Beam, or Capacity is greater than the value specified in the corresponding rule (MovingVesselLOA, MovingVesselBeam, MovingVesselCapacity).
2	Combined Beam Width; Two valid vessels are required. The rule is triggered if the combined beam width of the vessels is greater than the reach width multiplied by the fractional value specified in Parameter 1,
3	Combined Draft; Two valid vessels are required. The rule is triggered if the combined draft of the vessels is greater than the value specified in Rule Parameter 1
4	Capacity1: Capacity Limit V1 AND (Draft Limit OR Capacity Limit V2); Two valid vessels are required. The rule is triggered if a vessel above a certain capacity (MVCapacity) encounters another vessel that is above EITHER a draft (OVDraft) OR capacity (OVCapacity) limit. SYMMETRICAL
5	Capacity2: Capacity Limit V1 AND (Draft Limit AND Capacity Limit V2); Two valid vessels are required. The rule is triggered if a vessel above a certain capacity (MVCapacity) encounters another vessel that is above BOTH a draft (OVDraft) AND capacity (OVCapacity) limit. SYMMETRICAL
7	Capacity3: (Capacity AND Draft Limit V1) OR (Capacity AND Draft Limit V2); Two valid vessels are required. The rule is triggered if EITHER vessel is above respective limits for BOTH capacity AND draft. Four values are supplied: MV Capacity, MV Draft, OVCapacity, and OV Draft.
8	Critical Commodity Vessel; Two valid vessels are required. Rule violation for the moving vessel if the vessel in reach (OV) is a critical commodity vessel (typically LNG, LPG, NH3, Passenger) based on commodity category carried at any point in vessel call.
10	Two valid vessels are required. No movement if MV within safety zone distance of OV in the same reach. A Safety Zone Distance (feet) & a Safety Zone type are specified in association with commodity category. The rule determines if a safety zone applies.
11	Draft AND Combined Beam Width Limit; Two valid vessels are required. The moving vessel draft must exceed MV Draft and combined beam width must be greater than Rule Parameter 1
13	Draft Limit V1 Protocol Vessel V2; Two valid vessels are required. The moving vessel cannot encounter a protocol vessel in the reach if the MV draft exceeds the rule MV draft.
14	Any Vessel; Two valid vessels are required. The moving vessel cannot have the designated encounter (pass, overtake, meet) if there is any vessel in the reach.
16	Vessel Class V1 Protocol Vessel V2; Two valid vessels are required. A moving vessel of specified class (MV CLASS) cannot have the designated encounter with a protocol vessel in the reach
17	Draft Plus Tide; Single Vessel Rule. No movement allowed if vessel draft is greater than (Rule Parameter 2 + minimum tide during interval). Rule parameter 2 defines maximum allowable sailing draft on 0 tide. 0.001' tolerance is used.
18	Draft Limit; Single Vessel Rule. No movement if draft > MV Draft
19	Draft Range LOA Limit Current Limit; Single Vessel Rule. No sailing if MV draft in range between Rule MV Draft AND Rule P2 AND LOA > Rule MV LOA AND Current > P3
20	Draft Limit Current Limit; Single Vessel Rule. No sailing draft> MV Draft AND current>P3
21	LOA Limit Current Limit; Single Vessel Rule. No sailing if MV LOA > Rule MV LOA AND Current > P3
22	Directional Draft Limit Current Limit; Single Vessel Rule. No movement allowed in P1 direction if MV Draft > Rule MV Draft, Current >P3. P1 <0 inbound, P1 > =0 outbound
24	Directional Draft Limit LOA Limit; Single Vessel Rule. No movement allowed in P1 direction if MV LOA > Rule MV LOA, Current >P3. P1 <0 inbound, P1 > =0 outbound
25	Draft Plus Tide To Max Draft; Single Vessel Rule. No movement allowed if vessel draft is greater than (Rule Parameter 2 + minimum tide during interval). Rule parameter 2 defines maximum allowable sailing draft on 0 tide. 0.001' tolerance is used. MV Draft is max draft overall

Transit Rule Type No.	Transit Rule Type Description
26	Beam Reach Width Limit; Single Vessel Rule. No movement if MV Beam plus Rule Parameter 1 > Reach Width
27	Draft Exceeds Depth Using Tide / Underkeel; Single Vessel Rule. No movement if MV Draft plus underkeel > (depth plus minimum tide in period). Underkeel based on vessel class.
28	Vessel Class Beam Limit; Single Vessel Rule, no movement if class = rule vessel class and moving vessel beam > rule beam - single vessel rule, enter values for beam, class in MV fields
29	Vessel Class LOA Limit; Single Vessel Rule, no movement if class = rule vessel class and moving vessel LOA > rule LOA - single vessel rule, enter values for beam, class in MV fields
30	Draft Limit V1 OR Draft Limit V2; Two valid vessels are required. No movement if either MV draft > Rule MV Draft OR OV draft > Rule OV Draft. The rule is triggered if EITHER vessel is above respective limits for draft. Two valid values required, MV Draft, OV Draft
31	Safe Distance; Two valid vessels are required. No movement if MV within critical distance of OV. Critical distance specified either as P1 (fixed distance, feet) or P2 (MV LOA multiplier). Critical distance is larger of these two values.

Table 11: Vessel Traffic Rules – Number and Parameter Usage

Transit Rule Type No.	Transit Rule Description	P1 Usage Description	P2 Usage Description	P3 Usage Description
0	No Rule	N/A	N/A	N/A
1	Vessel LOA or Beam or Capacity	N/A	N/A	N/A
2	Combined Beam Width	decimal fraction of channel width (0 to 1.0)	N/A	N/A
3	Combined Draft	Maximum Combined Draft	N/A	N/A
4	Capacity1	N/A	N/A	N/A
5	Capacity2	N/A	N/A	N/A
7	Capacity 3	N/A	N/A	N/A
8	Critical Commodity Vessel	N/A	N/A	N/A
10	Maintain Safety Zone	N/A	N/A	N/A
11	Draft AND Combined Beam Width Limit	Combined Beam Width	N/A	N/A
13	Draft Limit V1 Protocol Vessel V2	N/A	N/A	N/A
14	Any Vessel	N/A	N/A	N/A
16	Vessel Class V1 Protocol Vessel V2	N/A	N/A	N/A
17	Draft Plus Tide	N/A	Maximum Sailing Draft Without Tide	N/A
18	Draft Limit	N/A	N/A	N/A
19	Draft Range	N/A	Max Draft	Max Current

Transit Rule Type No.	Transit Rule Description	P1 Usage Description	P2 Usage Description	P3 Usage Description
	LOA Limit Current Limit			
20	Draft Limit Current Limit	N/A	N/A	Max Current
21	LOA Limit Current Limit	N/A	N/A	Max Current
22	Directional Draft Limit Current Limit	<0 inbound >=0 outbound	N/A	Max Current
24	Directional Draft Limit LOA Limit	<0 inbound >=0 outbound	N/A	Max Current
25	Draft Plus Tide To Max Draft	N/A	Max Draft With Tide	N/A
26	Beam Reach Width Limit	Required Excess Width	N/A	N/A
27	Draft Exceeds Depth Using Tide / Underkeel	N/A	N/A	N/A
28	Vessel Class Beam Limit	N/A	N/A	N/A
29	Vessel Class LOA Limit	N/A	N/A	N/A
30	Draft Limit V1 OR Draft Limit V2	N/A	N/A	N/A
31	Safe Distance	Safe distance, feet	MV LOA multiplier	N/A

Table 12: Traffic Rules – Number and Moving Vessel Characteristics

Transit Rule Type No.	Transit Rule Description	Single Vessel Rule	Tide Type	Moving Vessel LOA	Moving Vessel Beam	Moving Vessel Capacity	Moving Vessel Draft	Moving Vessel Class ID	Other Vessel LOA	Other Vessel Beam	Other Vessel Capacity	Other Vessel Draft	Other Vessel ClassID
NOTE: Entries are only required where “YES” is marked in the fields below													
0	No Rule												
1	Vessel LOA or Beam or Capacity	YES		YES	YES	YES							
2	Combined Beam Width												
3	Combined Draft												
4	Capacity1					YES					YES	YES	
5	Capacity2					YES					YES	YES	
7	Capacity 3					YES	YES				YES	YES	
8	Critical Commodity Vessel												
10	Safety Zone												
11	Draft AND Combined Beam Width Limit												
13	Draft Limit V1 Protocol Vessel V2						YES						
14	Any Vessel												
16	Vessel Class V1 Protocol Vessel V2							YES					
17	Draft Plus Tide	YES	Tide										
18	Draft Limit	YES					YES						
19	Draft Range LOA Limit Current Limit	YES	Current	YES			YES						

Transit Rule Type No.	Transit Rule Description	Single Vessel Rule	Tide Type	Moving Vessel LOA	Moving Vessel Beam	Moving Vessel Capacity	Moving Vessel Draft	Moving Vessel Class ID	Other Vessel LOA	Other Vessel Beam	Other Vessel Capacity	Other Vessel Draft	Other Vessel ClassID
NOTE: Entries are only required where “YES” is marked in the fields below													
20	Draft Limit Current Limit	YES	Current				YES						
21	LOA Limit Current Limit	YES	Current	YES									
22	Directional Draft Limit Current Limit	YES	Current				YES						
24	Directional Draft Limit LOA Limit	YES	Current										
25	Draft Plus Tide To Max Draft	YES	Tide				YES						
26	Beam Reach Width Limit	YES											
27	Draft Exceeds Depth Using Tide / Underkeel	YES											
28	Vessel Class Beam Limit	YES			YES			YES					
29	Vessel Class LOA Limit	YES		YES				YES					
30	Draft Limit V1 OR Draft Limit V2						YES						

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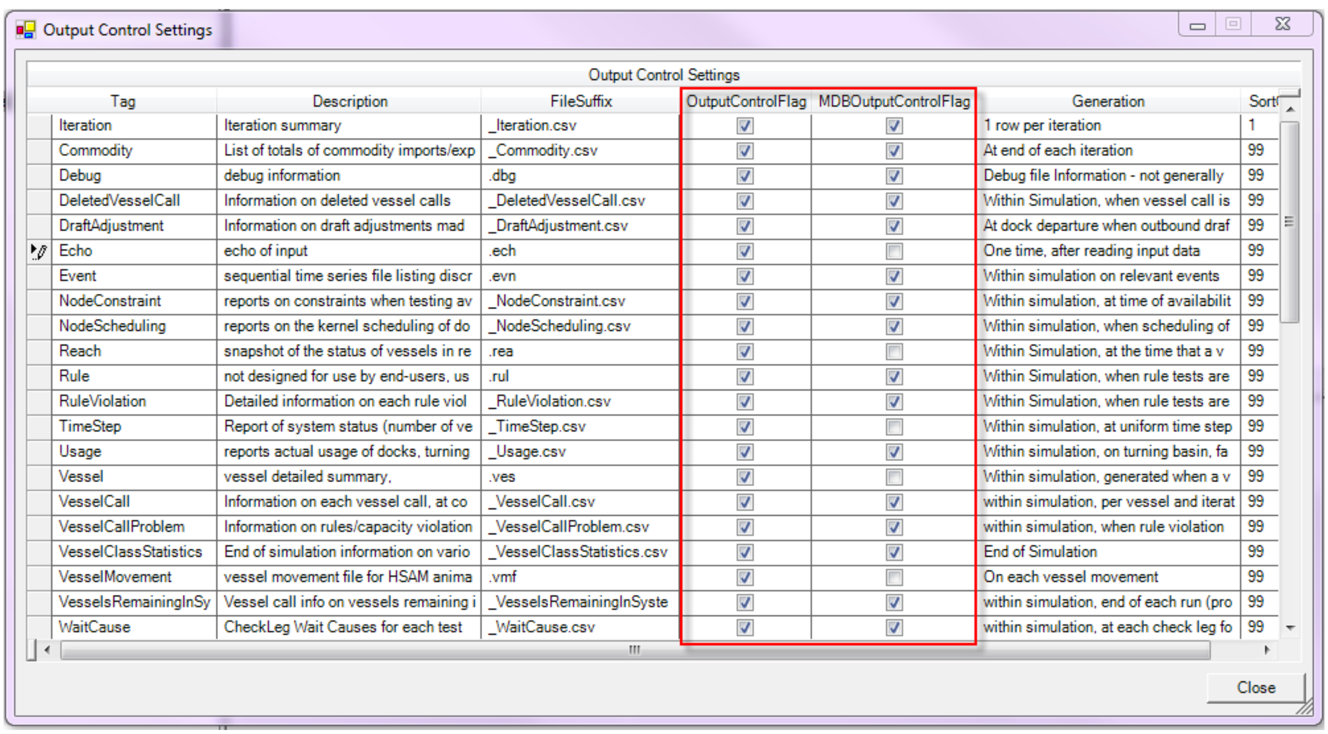
Appendix C

HarborSym Output Files

C.1 Setting Output Controls

The output controls settings of the scenario editor screen (Section 8.1) allows the user to determine which details from the scenario will be stored and reported after the simulation is complete. Users have the option for this information to be generated as text/ CSV files and also to be stored in a Microsoft Access database. Pressing "File Settings" on the scenario editor will launch the output control settings window. This table contains a description of the below listed files, including the file suffix. The user can select to output data to files (select "OutputControlFlag", as shown in Figure 113), which will generate text and CSV files, and/or to output data to database (select "MDBOutputControlFlag"), which will generate the same information in a database.



Tag	Description	FileSuffix	OutputControlFlag	MDBOutputControlFlag	Generation	Sort
Iteration	Iteration summary	_Iteration.csv	☑	☑	1 row per iteration	1
Commodity	List of totals of commodity imports/exp	_Commodity.csv	☑	☑	At end of each iteration	99
Debug	debug information	.dbg	☑	☑	Debug file Information - not generally	99
DeletedVesselCall	Information on deleted vessel calls	_DeletedVesselCall.csv	☑	☑	Within Simulation, when vessel call is	99
DraftAdjustment	Information on draft adjustments mad	_DraftAdjustment.csv	☑	☑	At dock departure when outbound draf	99
Echo	echo of input	.ech	☑	☐	One time, after reading input data	99
Event	sequential time series file listing discr	.evn	☑	☑	Within simulation on relevant events	99
NodeConstraint	reports on constraints when testing av	_NodeConstraint.csv	☑	☑	Within simulation, at time of availabilit	99
NodeScheduling	reports on the kernel scheduling of do	_NodeScheduling.csv	☑	☑	Within simulation, when scheduling of	99
Reach	snapshot of the status of vessels in re	.rea	☑	☐	Within Simulation, at the time that a v	99
Rule	not designed for use by end-users, us	.rul	☑	☑	Within Simulation, when rule tests are	99
RuleViolation	Detailed information on each rule viol	_RuleViolation.csv	☑	☑	Within Simulation, when rule tests are	99
TimeStep	Report of system status (number of ve	_TimeStep.csv	☑	☐	Within simulation, at uniform time step	99
Usage	reports actual usage of docks, turning	_Usage.csv	☑	☑	Within simulation, on turning basin, fa	99
Vessel	vessel detailed summary.	.ves	☑	☐	Within simulation, generated when a v	99
VesselCall	Information on each vessel call, at co	_VesselCall.csv	☑	☑	within simulation, per vessel and iterat	99
VesselCallProblem	Information on rules/capacity violation	_VesselCallProblem.csv	☑	☑	within simulation, when rule violation	99
VesselClassStatistics	End of simulation information on vario	_VesselClassStatistics.csv	☑	☑	End of Simulation	99
VesselMovement	vessel movement file for HSAM anima	.vmf	☑	☐	On each vessel movement	99
VesselsRemainingInSy	Vessel call info on vessels remaining i	_VesselsRemainingInSyste	☑	☑	within simulation, end of each run (pro	99
WaitCause	CheckLeg Wait Causes for each test	_WaitCause.csv	☑	☑	within simulation, at each check leg fo	99

Figure 113: Output Control Settings

This database will be created in the directory where the project files are stored, and will have the file extension .SODA. The database can be opened using Microsoft Access. For additional information on the Output Control Settings see Table 13.

Table 13: Output Control/Settings

OutputControl ID	Tag	Description	FileSuffix	Generation	OutputControl Flag	MDBOutput ControlFlag	SortOrder
1	Debug	debug information	.dbg	Debug file Information - not generally user-friendly	0	0	99
2	Echo	echo of input	.ech	One time, after reading input data	0	0	99
3	VesselMovement	vessel movement file for HSAM animation	.vmf	On each vessel movement	0	0	99
4	Event	sequential time series file listing discreet events during the simulation	.evn	Within simulation on relevant events	0	0	99
5	Reach	snapshot of the status of vessels in reaches	.rea	Within Simulation, at the time that a vessel enters or leaves a reach	0	0	99
6	Vessel	vessel detailed summary,	.ves	Within simulation, generated when a vessel call departs the system	0	0	99
7	Rule	not designed for use by end-users, used for checking of rule operation	.rul	Within Simulation, when rule tests are made (vessel enters leg)	0	0	99
8	RuleViolation	Detailed information on each rule violation	_RuleViolation.csv	Within Simulation, when rule tests are made (vessel enters leg)	0	0	99
9	DraftAdjustment	Information on draft adjustments made at dock when needed	_DraftAdjustment.csv	At dock departure when outbound draft is calculated	0	0	99
10	Commodity	List of totals of commodity imports/exports by commodity type and iteration	_Commodity.csv	At end of each iteration	-1	-1	99
11	TimeStep	Report of system status (number of vessels in system, total times for waiting, etc.) by time step within iteration	_TimeStep.csv	Within simulation, at uniform time step	0	0	99
12	DeletedVesselCall	Information on deleted vessel calls	_DeletedVesselCall.csv	Within Simulation, when vessel call is deleted due to delay beyond limits	-1	-1	99
13	NodeConstraint	reports on constraints when testing availability of docks, turning area, facility node	_NodeConstraint.csv	Within simulation, at time of availability test	0	0	99
14	Usage	reports actual usage of docks, turning areas, facility nodes	_Usage.csv	Within simulation, on turning basin, facility node, or dock departure	0	0	99
15	NodeScheduling	reports on the kernel	_NodeScheduling	Within	0	0	99

OutputControl ID	Tag	Description	FileSuffix	Generation	OutputControl Flag	MDBOutput ControlFlag	SortOrder
		scheduling of docks, turning areas, facility nodes,	.csv	simulation, when scheduling of nodes takes place			
16	Iteration	Iteration summary	_Iteration.csv	1 row per iteration	-1	-1	1
17	VesselClassStatistics	End of simulation information on various average vessel time statistics, by vessel class	_VesselClassStatistics.csv	End of Simulation	0	0	99
18	VesselCall	Information on each vessel call, at completion of vessel call	_VesselCall.csv	within simulation, per vessel and iteration	0	0	99
19	VesselCallProblem	Information on rules/capacity violations/draft adjustments for a vessel call	_VesselCallProblem.csv	within simulation, when rule violation or constraint noted	0	0	99
20	UnitOfMeasure	Commodity summary by unit of measure, iteration	_UnitOfMeasure.csv	at end of each iteration	0	0	99
21	DraftAdjustment2	Detailed information on draft adjustments / exceptions	_DraftAdjustment2.csv	within simulation, at draft adjustment	0	0	99
22	VesselsRemainingInSystem	Vessel call info on vessels remaining in system at end of iteration (separate for priority and regular runs)	_VesselsRemainingInSystem.csv	within simulation, end of each run (priority and total) for each iteration	-1	0	99
23	WaitCause	CheckLeg Wait Causes for each test	_WaitCause.csv	within simulation, at each check leg for each iteration	0	0	99
24	WaitCause2	CheckLeg Wait Causes Summary	_WaitCause2.csv	within simulation, at each check leg for each iteration	0	0	99
25	RouteGroupStatistics	End of simulation information on various average route group statistics	_RouteGroupStatistics.csv	End of simulation	0	0	99

C.2 ASCII Output Files

There are multiple files designed to assist the user and track the output of simulations. The files are the summary (print) file, vessel output file, the event output file, the debug output file, the reach output file, the post-processing animation file, the detailed vessel file, and the rules/debug output file. The output files contain the port name and the study name in their heading. Although each has a unique file name, these are all text files and can be opened with any text editor. Following a simulation, the user can locate these files in the same location as the project databases. Each time a simulation is run with the same scenario name, the files are recreated and previous files are overwritten. With the exception of the summary file, these files are primarily used for detailed investigation and debugging, and are not formatted for user reporting. Note that, for long simulations with many vessels, these files can grow very large, in particular the debug, event, rule, and reach files.

C.2.1 Summary File .prn

The summary file, identified by the .prn extension, provides useful overview statistics of the simulation. An annotated .prn file is included in Section C.5.

C.2.2 Vessel Output File .ves

This file contains a listing of the transits of each vessel. The Leg of each transit by the vessel is listed. A leg is a vessel transit from entrance to destination, a transit between destinations within the harbor, or a transit from destination to the harbor exit.

C.2.3 Event Output File .evn

This file lists each event sequentially. The first column is the iteration number and the second column is the time of the event, listed by the number of hours since the start of the simulation.

C.2.4 Reach Output File .rea

This file lists the entrance time and exit time of each reach transit by each vessel.

C.2.5 Debug Output File .dbg

This file lists each calculation during the course of a simulation. The increments of commodity transfer and the transit time calculations for each vessel are shown.

C.2.6 Rule Violation .rul

This file lists rule violations by leg transited by each vessel.

Check Leg	A Ship Protocol Run:	N Leg	Entry Time:	26.000	VCall:	V Number:	Leg:	
End Check Leg	Rule Violations:	0	Segment Start:	0	End:	Farthest	LegBlock:	Blocking Segment:

C.2.7 Echo of Input .ech

This file lists an echo of the input data.

C.2.8 Vessel Movement .vmf

This file is the vessel movement file for HSAM animation.

C.2.9 Error File.err

This file provides an overview of the model inputs used during the simulation, including number of reaches, nodes, docks, commodity categories, commodity transfers, etc. The report will also outline errors and warnings that may impact the model's functionality. It should be noted that this report does not provide a comprehensive review of all data issues that may cause problems with the simulation. The Data Validator (Section 5.7.5 and 6.11) provides a pre-processing data review.

C.3 .csv Files in Excel® and Access® Format

The simulation runs result in several detailed output files which the user can review in Microsoft Excel or Access. As shown in Figure 113, the user can request the detailed output to be generated in .CSV format, in an Access database, or both. The files contain the same information in the .csv format or the Access .SODA; the selection of one format over another is simply a matter of user preference. The detailed information contained in these files is best used for understanding behavior of specific vessels or traffic patterns. As such, many of these files are best used for single iteration testing.

C.3.1 Iteration .csv

This file contains the same information as in the single scenario report, broken out by iteration. Note that in order for the Vessel Time graph (available after running the simulation under the Output/Graphs menu option) to display the correct average vessel time, the user must select the 'Iteration.csv' output option when running the simulation.

HEADING	DESCRIPTION
Iteration	Number of iteration, starting at one for the first iteration
Calls	Number of vessels calling on harbor during iteration
Exiting	Number of vessels exiting harbor during iteration
Deleted	Number of vessels deleted during iteration
Total Time In System	Total time all vessels spent in the harbor
Total Time In Reaches	Total time all vessels spent in harbor reaches
Total Time Docking	Total time all vessels spent docking
Total Time Undocking	Total time all vessels spent undocking
Total Time Loading Unloading	Total time all vessels transferring commodities
Total Time Turning Basin	Total time all vessels spent in turning basins
Total Time Waiting At Entrance	Total time all vessels spent waiting to enter harbor
Total Time Waiting At Dock	Total time all vessels spent waiting to leave docks

HEADING	DESCRIPTION
Total Time Waiting At Turning Basin	Total time all vessels spent waiting in turning basins
Total Time Waiting At Facility Nodes	Total time all vessels spent waiting in facility nodes
Total Vessel Time Waiting All Sources	Total time all vessels spent waiting anywhere
Total Time	Total time all vessels spent anywhere
Total Commodity Tons Export	Total tons for all commodities exported
Total Commodity Tons Import	Total tons for all commodities imported
Total Commodity Tons	Total tons for all commodities imported and exported
Total Commodity Value Export	Total value for all commodities exported
Total Commodity Value Import	Total value for all commodities imported
Total Commodity Value	Total value for all commodities imported and exported
Total Cost Port	Total cost for all vessels while in port
Total Cost At Sea	Total cost for all vessels while at sea
Total Overall Cost	Total overall cost for all vessels while at sea and in port
Average Vessel Time	Average time a vessel spent in the harbor
Max Vessel Time	Maximum time any vessel spent in the harbor
Min Vessel Time	Minimum time any vessel spent in the harbor
SD Vessel Time	Standard deviation of time spent by vessels in harbor
Total Allocated Cost To Port	Total cost allocated to subject port, expressed in 1,000s
Total Voyage Cost Allocated to Port	Total at-sea voyage cost allocated to subject port, expressed in 1000s

C.3.2 RuleViolation.csv

The Rule Violation file lists all details of vessel traffic rule triggers that occurred during the simulation. The scenario name and project simulated are included in the output file name. The rule violation data provided is listed below by column heading.

HEADING	DESCRIPTION
Iteration	Number of the iteration, starting at one for the first iteration
Priority Run	Flag to indicate if the data was generated during the priority vessel run

HEADING	DESCRIPTION
	(0 if not priority run, 1 if priority run)
Current Time	Time measurement in hours of time into iteration
Situation	Description of vessel situation when rule was triggered (arrival, DD= dock delay, FD= facility delay)
Location	Specific node where vessel was located when rule trigger occurred
MV Vessel Call ID	Vessel call ID number of the moving vessel
MV Vessel Number	External identifier number of the moving vessel
MV Name	Name of the moving vessel
Reach	Reach number for the reach where the rule violation occurred
Reach Description	Name of reach where the rule violation occurred
Rule Number	Number of the vessel transit rule triggered
Port Rule	Y/N flag to indicate if a port level rule was triggered
Transit Rule Number	Rule number of rule implemented for the reach
Rule Description	Description of the rule violated
Applicable Condition	The condition for rule application previously selected by the user
MV LOA	LOA of the moving vessel, in feet
MV Beam	Beam of the moving vessel, in feet
MV Capacity	Capacity of the moving vessel, units as expressed in vessel call list
MV Draft	Draft of the moving vessel, in feet
MV Type	Vessel type name of the moving vessel
MV Class ID	Vessel class ID number of the moving vessel
MV Class	Vessel class of the moving vessel
MV Underkeel	Underkeel clearance allowed for the moving vessel, in feet
OV Vessel Call ID	Vessel call ID number of the other vessel (-1 default)
OV Vessel Number	Identifier Number of the Other Vessel
OV Name	Name of the Other Vessel

HEADING	DESCRIPTION
OV LOA	LOA of the Other Vessel, in feet
OV Beam	Beam of the Other Vessel, in feet
OV Capacity	Capacity of the Other Vessel, units as expressed in vessel call list
OV Draft	Draft of the Other Vessel, in feet
OV Type	Type of the Other Vessel
OV Class ID	ID number of the Vessel Class
OV Class	Class of the Other Vessel
Status	0 indicates no conflict (no other vessel is involved)
	1 indicates passing (2 vessels moving in opposite directions)
	2 indicates overtaking (2 vessels moving in the same direction)
	3 indicates overtaken (2 vessels moving in the same direction)
OV Priority	0 for non-protocol, 1 for protocol vessel
Rule Parameter 1, 2, 3	Parameters of the rule triggered
MV Reach Entry Time	Simulation Time That Moving Vessel Enters Reach
MV Reach Exit Time	Simulation Time That Moving Vessel Exits Reach
Reach Width	Width of Reach Where Rule Violation Occurred, in feet
Reach Depth	Depth of Reach Where Rule Violation Occurred, in feet
Minimum Tide	Minimum depth availability due to tide, in feet
Maximum Tide	Maximum depth availability due to tide, in feet
Message	Description of rule trigger conditions

C.3.3 Draft Adjustment.csv

This Excel spreadsheet lists the details of draft changes in vessels that exceed the minimum or maximum draft for their vessel class. The column headings are listed below.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Time	Hours into simulation starting at one

HEADING	DESCRIPTION
Vessel Call ID	ID number of vessel call, assigned by HarborSym
Vessel Number	ID number of the vessel in the vessel call
Vessel Class	Vessel classification of the vessel in the vessel call
Vessel Name	Name of vessel in vessel call
Dock	Name of dock
Dock Visit	Dock visit ID, not used at this time
Bar Arrival Draft	Draft when arriving at bar, in feet
Dock Arrival Draft	Draft when arriving at dock, in feet
Tons Commodity Transfer	Tons of commodity imported/exported
TPI	Tons per square inch immersion factor
Draft Change	Change in draft (feet) resulting from commodity transfer
Tentative Draft	Tentative calculated draft, in feet
Final Draft	Final draft after adjustment, in feet
Class Minimum Draft	Minimum Draft for Vessel Classification, in feet
Class Maximum Draft	Maximum Draft for Vessel Classification, in feet
Underkeel Clearance	Underkeel Clearance for Vessel Classification, in feet
Next Leg Critical Value	Draft for next critical leg, in feet
Min Controlling Value Next Leg	Minimum value allowed at next leg
Message	Detailed message area

C.3.4 DeletedVesselCall.csv

This file provides a list of the vessel calls deleted because the vessel was unable to move after the specified number of retries.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Time	Hours into simulation, in fractions

HEADING	DESCRIPTION
PriorityRun	Indicates whether the call is priority run vessel
Vessel Call ID	The vessel call ID Number
Vessel Name	Name of vessel deleted in the vessel call
Situation	What is occurring to cause vessel call to be deleted
Location	Location of vessel when vessel call deleted
InitialDraft	Initial draft of vessel, in feet
CurrentDraft	Current draft of vessel, in feet
NextLegCriticalValue	Available sailing depth for next critical leg, in feet
Route	Details on vessel route

C.3.5 Commodity.csv

This file lists the total imports and exports of each commodity category during each iteration. This file is useful in determining that all commodities in the vessel call list are properly imported and exported.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Commodity	Name of commodity category
Actual Import In Iteration	Total tons of commodity category imported during iteration
Total Import In VCDB	Total Tons of Commodity Imported in Vessel Call List
Actual Export In Iteration	Total tons of commodity category exported during iteration
Total Export In VCDB	Total Tons of Commodity Exported in Vessel Call List

C.3.6 VesselClassStatistics.csv

This file lists the average, minimum and maximum for each statistic for each vessel class.

HEADING	DESCRIPTION
Statistic	Description of Statistic
Class	Name of Vessel Class
ID1	Additional details such as commodity units

HEADING	DESCRIPTION
N	Number of Exiting Vessels of Each Vessel Class
Average	Average of the Statistic
SD	Standard Deviation of the Statistics
Maximum	Maximum of the Statistic
Minimum	Minimum of the Statistic
AvgCost	Average Cost for the Statistic and Vessel Class
SDCost	Standard deviation of Cost for the Statistic and Vessel Class
MaxCost	Maximum Cost for the Statistic and Vessel Class
MinCost	Minimum Cost for the Statistic and Vessel Class

C.3.7 VesselCall.csv

This file lists detailed information for every vessel call. The route reported in the VesselCall.csv file is not the actual route taken by the vessel, but the calculated set of key nodes (entry, docks, turning basins, exit) to be visited at the start of the vessel call. Anchorages are not included in this, because anchorage visits are calculated within the simulation. To view the complete route including anchorages, please see the Event Output file (evn).

HEADING	DESCRIPTION
Iteration	Number of Iteration
Priority Run	0 if not priority run, 1 if priority run
Priority Vessel	0 if not priority vessel, 1 if priority vessel
Name	Name of Vessel
Class	Class of Vessel
Route	Route group for vessel call
Prior Port Distance	Distance of prior port, in nautical miles
Next Port Distance	Distance of next port, in nautical miles
Additional Sea Distance	Additional sea distance, in nautical miles
Vessel Counter	Count of Vessels Within Iteration
Vessel Call ID	Vessel Call ID Number

HEADING	DESCRIPTION
Vessel ID	Vessel ID Number
Number of Dock Visits	Number of different docks visited within a vessel call
Arrival Time	Simulation Time that Vessel Arrives at Harbor
Entry Time	Simulation Time that Vessel Begins Transit Through the First Reach
Exit Time	Simulation Time that Vessel Exits Harbor
Net Time	Difference Between Entry Time and Exit Time, in hours
Total Time	Not Used
Delay Count	Count of times vessel delayed
Time Waiting Dock	Amount of Time Spent Waiting to Leave the Dock, in hours
Time At Dock	Amount of Time Spent Loading And Unloading, in hours
Time Docking	Amount of Time Spent Docking, in hours
Time Undocking	Amount of Time Spent Undocking, in hours
Time Wait at Entry	Amount of Time Between Arrival and Entry, in hours
Time At Turning Basin	Amount of Time Spent Turning, in hours
Time Waiting Facility Node	Amount of Time Spent Waiting at Anchorages, in hours
Time Total In Reaches	Amount of Time Spent Transiting Through Reaches, in hours
Time at Sea	Amount of Time Spent at Sea, in hours
Total Sea Distance	Total Sea Distance Traveled, in nautical miles
Speed at Sea	Average Speed at Sea, in knots
Time Cost at Sea	Time at Sea Cost Applied, in hours
Time Cost in Port	Time in Port Cost Applied, in hours
Total Time Cost	Total Time Cost Applied, in hours
Export Tons	Total Tons Exported
Import Tons	Total Tons Imported
Total Tons	Total Combined Tons Imported and Exported

HEADING	DESCRIPTION
Retained Tonnage	Tonnage Retained on Vessel
Export Value	Value of Exports
Import Value	Value of Imports
Total Value	Total Combined Value of Exports and Imports
Retained Value	Value Retained on Vessel
ETTC	Estimate of total trip cargo, defined as quantity on board the vessel at arrival plus cargo on board the vessel at departure
Hourly Cost In Port	Per Hour Cost to Vessel While in Port
Hourly Cost At Sea	Per Hour Cost to Vessel While at Sea
Arrival Draft	Draft of Vessel When Arriving at Port, in feet
Departure Draft	Draft of Vessel When Departing Port, in feet
Total Outbound Tonnage	Tonnage of Vessel When Departing Port
Import Share Weight By Route Group	Percent of Imports for Route Group
Import Cost Allocation Share	Fraction of Import Costs Associated with At-Sea Costs to be Allocated to Subject Port
Export Cost Allocation Share	Fraction of Export Costs Associated with At-Sea Costs to be Allocated to Subject Port
Separable Cost	Costs that Are Fully Allocated to Subject Port
Allocated Import Costs	Import Costs Allocated to Subject Port (time cost at sea times import cost allocation share)
Allocated Export Costs	Export Costs Allocated to Subject Port (time cost at sea times export cost allocation share)
Voyage Costs Allocated to Subject Port	Weighted average voyage costs allocated to subject port, average of allocated import costs and allocated export costs
Allocated Total Cost To Subject Port	Total Cost to Vessel Allocated to Port of Study, sum of weighted voyage costs and separable costs
Time Cost In Reaches	Costs Associated with Waiting Time at Reaches
Time Cost Waiting At Entry	Costs Associated with Waiting Time at Entry

HEADING	DESCRIPTION
Time Cost Docking	Costs Associated with Docking Time
Time Cost Undocking	Costs Associated with Undocking Time
Time Cost At Dock	Costs Associated with Time at Docks
Time Cost Waiting At Dock	Costs Associated with Waiting Time at Docks
Time Cost Waiting At Turning Basin	Costs Associated with Waiting Time at Turning Basin
Time Cost At Turning Basin	Costs Associated with Turning Time
Time Cost Waiting At Facility Node	Costs Associated with Waiting Time at Facility Nodes
Cost Total Port	Total Cost While in Port, total voyage
Cost Total At Sea	Total Cost While at Sea, total voyage
Cost Overall Total	Total Overall Cost for Voyage
Foreign	Indicator of Foreign Vessel
Vessel Path	Path Traversed by Vessel

C.3.8 NodeConstraint.csv

This file reports on constraints when testing availability of docks, turning areas and facility nodes.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Time	Hours into simulation, in fractions
Protocol	0 if not protocol vessel, 1 if protocol vessel
Priority	Not Used
Vessel Call ID	Vessel Call ID Number
Leg	Indicates whether vessel is located in leg
Vessel	Name of vessel call
Class	Name of Vessel Class
VSU	Number of vessel size units

HEADING	DESCRIPTION
Loaded	Indicates whether vessel is loaded
Draft	Current draft of vessel, in feet
Test Draft	Draft (feet) after commodity transfer based on TPI and exiting load
Underkeel	Indicates the minimum clearance available between the deepest point on the vessel and the bottom in still water
Facility	Name of facility
Type	Type of facility
Depth	Depth of vessel in water
Min Tide	Depth Adjustment
Capacity	Capacity of vessel
Vessels	Number of vessels
VSU Capacity	Capacity of vessel size units
VSU Capacity Used	Amount of capacity used in vessel size units
Code	Capacity code

C.3.9 NodeScheduling.csv

This file reports on the kernel scheduling of docks, turning areas, and facility nodes.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Time	Hours into simulation, in fractions
Protocol	0 if not protocol vessel, 1 if protocol vessel
Priority	Not Used
Vessel Call ID	Vessel Call ID Number
Leg	Indicates whether vessel is located in leg
Vessel	Name of vessel call
Class	Name of Vessel Class
VSU	Number of Vessel Size Units

HEADING	DESCRIPTION
Facility	Name of facility
Type	Type of facility
Capacity	Capacity of vessel
Capacity VSU	Capacity of Vessel Size Units
Vessels In Facility	Number of vessels in facility
Vessels Waiting In Facility	Number of vessels waiting in facility
VSU Used	Vessel Size Units used
Entry Time	Simulation Time that Vessel Begins Transit Through the First Reach
Exit Time	Simulation Time that Vessel Exits Harbor

C.3.10 TimeStep.csv

This file reports on system status (number of vessels in system, total time waiting, etc.) by time step.

HEADING	**DESCRIPTION**
Iteration	Iteration number, starting at one
Time	Hours into simulation, in fractions
Vessel In System	Number of vessels in system
Entry Wait	Amount of Time Between Arrival and Entry
In Reach	Indicates whether a vessel is located in a reach
Dock	Indicates whether a vessel is located at a dock
Dock Wait	Indicates whether a vessel is waiting at a dock
Turning Basin	Indicates whether a vessel is located in a turning basin
Turning Basin Wait	Indicates whether a vessel is waiting at a turning basin
Facility Node	Indicates whether a vessel is located at a facility node
Facility Node Wait	Indicates whether a vessel is waiting at a facility node
Total Vessel Time	Total time vessel spent at port
Total Tons Loaded	Number of tons loaded onto the vessel

HEADING	DESCRIPTION
Total Tons Off Loaded	Number of tons off loaded
Total Commodity	Number of tons of commodity off loaded
Commodity Per Time	Amount of commodity off loaded per time

C.3.11 Usage.csv

This file reports the actual usage of docks, turning areas, facility nodes.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Protocol	0 if not protocol vessel, 1 if protocol vessel
Priority	Not Used
Vessel Call ID	The vessel call ID Number
Leg	Indicates whether vessel is located in leg
Vessel	Name of Vessel Call
Class	Name of Vessel Class
VSU	Vessel Size Units
Node	Name of the node
Type	Type of port structure
Entry Time	Simulation Time that Vessel Begins Transit Through the First Reach
Exit Time	Simulation Time that Vessel Exits Harbor
Vessel Total	The total number of vessels
VSU Total	The total number of vessel size units
Capacity Code	Capacity code

C.3.12 VesselCallProblem.csv

This file reports provides information on rules, capacity violations and draft adjustments for a vessel call.

HEADING	DESCRIPTION

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Protocol	0 if not protocol vessel, 1 if protocol vessel
Time	Hours into simulation, in fractions
Vessel Call ID	The vessel call ID Number
Vessel Name	Name of vessel
Class	Name of Vessel Class
Beam	Length of Vessel Beam, in feet
LOA	Overall Length of a Vessel, in feet
Capacity	Capacity of the vessel, as expressed in vessel call list
TPI	The number of tons that can be placed on a vessel to cause the vessel to sink bodily in the water by one inch
Initial Draft	Draft entering harbor, in feet
Current Draft	Test Draft or Maximum / Minimum Draft for Vessel Class, in feet
Problem Type	The vessel call problem type
Status	0 indicates no conflict (no other vessel is involved)
	1 indicates passing (2 vessels moving in opposite directions)
	2 indicates overtaking (2 vessels moving in the same direction)
	3 indicates overtaken (2 vessels moving in the same direction)
Detail	Details concerning the vessel call problem
Message	Message regarding the vessel call issue

C.3.13 VesselsRemainingInSystem.csv

This file reports information on vessels remaining in system at end of iteration

.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Protocol	0 if not protocol vessel, 1 if protocol vessel
Priority	Not Used
Name	Name of Vessel
Class	Name of Vessel Class
Count	Count of Vessels Within Iteration
Call ID	Vessel Call ID Number
Vessel ID	Vessel ID Number
Number Of Dock Visits	Number of different docks visited within a vessel call
Arrival Time	Simulation Time that Vessel Arrives at Harbor
Entry Time	Simulation Time that Vessel Begins Transit Through the First Reach
Exit Time	Simulation Time that Vessel Exits Harbor
Net Time	Difference Between Entry Time and Exit Time
Total Time	Not Used
Waiting Dock	Amount of Time Spent Waiting to Leave the Dock
At Dock	Amount of Time Spent Loading And Unloading
Docking	Amount of Time Spent Docking
Undocking	Amount of Time Spent Undocking
Wait At Entry	Amount of Time Between Arrival and Entry
At Turning Basin	Amount of Time Spent Turning
Waiting Facility Nodes	Amount of Time Spent Waiting at Facility Nodes
Total In Reaches	Amount of Time Spent Transiting Through Reaches

C.3.14 WaitCause.csv

This file documents vessel time, location, and cause of vessel delays. Multiple entries for the same vessel call at identical time stamps indicate more than one rule was triggered and caused the delay.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Priority Run	Flag to indicate if the data was generated during the priority vessel run (0 if not priority run, 1 if priority run)
Priority Vessel	Flag to indicate if the individual vessel is identified as a priority vessel (0 if not priority vessel, 1 if priority vessel)
Current Time	Time stamp of rule violation / trigger
Vessel Call ID	Vessel Call ID Number
Rule Type Number	Rule type that causes the delay
Reach Number	Reach where rule was triggered
Rule Type	General rule type
Wait Increment	Duration of delay
Situation	General location of vessel when rule was triggered (arrival, dock departure, anchorage departure)
Location	Specific location of vessel when rule trigger occurred (named node in network)
Delay Counter	Count of discrete number of times the vessel is place in wait status

C.3.15 WaitCause2.csv

This file documents vessel time, location, and cause of vessel delays in greater detail than the WaitCause.csv file. The number of triggers is identified by specific cause, as defined in Table 2.

This file is generated during the simulation and is a record of delays incurred by all vessels entering the system – including deleted vessel calls and vessels remaining in the system at the end of the simulation. As such, the result of summing the “Wait Increment” field in this table may not match the total delays reported in the .prn or other summary files. To match the outputs, remove delays incurred by deleted vessel calls or vessels remaining in the simulation. Two queries in the .SODA file (Section C.4) provide filtered versions of the Wait Cause 2 file.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Priority Run	Flag to indicate if the data was generated during the priority vessel run (0 if not priority run, 1 if priority run)
Priority Vessel	Flag to indicate if the individual vessel is identified as a priority vessel (0 if not priority vessel, 1 if priority vessel)
Current Time	Time stamp of rule violation / trigger
Vessel Call ID	Vessel Call ID Number
Situation	General location of vessel when rule was triggered (arrival, dock departure, anchorage departure)
Location	Specific location of vessel when rule trigger occurred (named node in network)
Delay Counter	Count of discrete number of times the vessel is place in wait status
Wait Increment	Duration of delay
Total Causes	Number of rule/reach combinations contributing to the delay
Combined Code	Numerical representation of combined delay code
Combined String	Combined delay code using the abbreviations in Table 2
VSC, C, BZ, T, AVSU. AVN. AD, TAVN, TAD, TAVSU, DVSU, DVN	General rule type, as defined in Table 2; number entry represents the number of rule triggers of that type contributing to the delay

C.3.16 UnitOfMeasure.csv

As commodities are transferred at each dock visit of each vessel call, HarborSym stores the units transferred, tons transferred, and value transferred for each commodity transfer. Units of measure for each commodity, value per unit, and tons per unit are defined by commodity category. A calculated cost is also determined for each vessel call, based on time spent in the various phases of activity at the port and at sea, when the vessel exits the system. At the end of each iteration, information is presented in the unit of measure file that rolls up this information for each distinct unit and vessel class, as well as providing totals by unit.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
UnitOfMeasure	Unit of measure (Tons, Passengers, Containers, etc)

HEADING	DESCRIPTION
VesselClass	Vessel classification of the vessel in the vessel call
UnitsImported	Number of commodity units imported
UnitsExported	Number of commodity units exported
TotalUnits	Number of commodity units imported plus exported
ValueImported	Dollar value of commodities imported
ValueExported	Dollar value of commodities exported
TotalValue	Dollar value of commodities imported/exported
TonsImported	Total tons imported
TonsExported	Total tons exported
TotalTons	Total tons, sum of total tons imported and total tons exported
AllocatedCostByImportTons	Portion of total voyage costs allocated to import tonnage transferred
AllocatedCostByExportTons	Portion of total voyage costs allocated to import tonnage transferred
TotalCostByTonsCheckSum	Sum of allocated costs by tons (import and export)
AllocatedCostByImportValue	Portion of total voyage costs allocated to import value transferred
AllocatedCostByExportValue	Portion of total voyage costs allocated to export value transferred
TotalCostByValueCheckSum	Sum of Allocated Cost by value (import and export)
CostPerTonImport	Allocated Cost By Import Tons/Tons Imported
CostPerTonExport	Allocated Cost By Export Tons/Tons Exported
CostPerTonTotal	Total Cost / Total Tons
CostPerValueImport	Allocated Cost By Import Value/Value Imported
CostPerValueExport	Allocated Cost By Export Value/Value Exported
CostPerValueTotal	Total Value / Total Tons

C.3.17 DraftAdjustment2.csv

This optional output reporting file provides detailed information on draft adjustments made when commodity transfers at a dock take place. Drafts are internally adjusted in the model to prevent vessels from getting "stuck" at the dock due to bad or inconsistent input data. This allows the model to proceed with the simulation.

When a draft adjustment is made following a commodity transfer at a dock, the tentative draft (incoming draft adjusted by commodity tonnage-associated draft change) is checked against the following in turn, and a code is applied to indicate if a draft adjustment is made based on the particular constraint.

Constraint on Tentative Draft	Adjustment Code
No Adjustment	0
<= class-based MaximumSailingDraft	1
<= Controlling Depth for next leg	2
<= unique vessel-based Design Draft	4
>= class-based MinimumSailingDraft	8

The sequence of adjustments is reported in the "Constraint Type" column. The adjustment code is a binary code indicating which combination of the 4 possible adjustments is made. The codes, and the order in which the adjustment is tested, are as follows:

0 = no adjustments,

1=adjust to max sailing draft

2=adjust to next leg critical value

4=adjust to design draft

8=adjust to minimum sailing draft

The binary code is the sum of each adjustment that is made, thus it takes on a possible range from 0 to 15, but not all combinations are logical, assuming rational values for design and class drafts.

This file is a companion to the _DraftAdjustment.csv file, providing some additional information in a slightly different format, to allow for checking of the draft adjustment process. Output can easily be filtered for a single vessel to show the draft changes and adjustments through the vessel call, from arrival to each dock visit.

HEADING	DESCRIPTION
Iteration	Iteration Number
Time	Current Time (decimal days from start date)
PriorityRun	1 = priority run, 0 = non-priority run
VesselCallID	Vessel Call ID
Dock	Dock Code
DockOrder	Order of Dock Visit in vessel call (-1 if situation is reported at arrival at the bar, 0 for first dock, 1 for 2nd dock visited, etc.)
ArrivalDraft	Arrival draft in feet at the location (bar, dock)

HEADING	DESCRIPTION
NetTonnageTransfer	Net tonnage transfer across all commodities transferred (import to the port is positive, export from port is negative)
TPI	TPI factor for vessel (tons per inch)
PreConstraintCalculatedDraft	Calculated draft based on commodity transfer and TPI, in feet
PostConstraintRevisedDraft	Draft after applying constraints, in feet
Situation	Arrival or Dock
ConstraintType	Text description of adjustment(s) made
AdjustmentCode	Binary adjustment code
ImpliedTonnageAdjustment	Total implied tonnage change given the draft adjustment, based on TPI (positive implies additional cargo on board, negative implies reduced cargo on board)

C.3.18 RouteGroupStatistics.csv

This file lists the average, minimum and maximum for each statistic for each route group.

HEADING	DESCRIPTION
Statistic	Description of Statistic
Route Group	Name of Route Group
ID1	Additional details such as commodity units
ID2	Additional details
Observation	Number of observations used to create statistic
StatisticAverage	Average of the Statistic
SD	Standard Deviation of the Statistics
StatisticMax	Maximum of the Statistic
StatisticMin	Minimum of the Statistic

C.4 .SODA Database

The Access database with the .SODA extension contains scenario-specific detailed output files. The data contained in the aforementioned .csv files (Sections C.3.1 through C.3.17) can be accessed directly through the .SODA database if the user selects the “MDB Output Control Flag” in the Output Control

Settings window. In addition to the .csv files, several pre-programmed queries are available in the .SODA for easy analysis of scenario data. The following subsections describe these queries, which can be viewed and modified directly in Microsoft Access.

C.4.1 qryFacilityNodeUsageByPath

The Facility Node Usage by Path query reports the anchorage usage by vessel call. This query allows the user to understand which vessels were directed to anchorages and the duration spent waiting at the anchorage for each vessel call.

For this query to function the Usage and Individual Vessel Call outputs must be generated during the simulation using the MDB Output Control flag.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Priority Run	Flag to indicate if the data was generated during the priority vessel run (0 if not priority run, 1 if priority run)
Priority Vessel	Flag to indicate if the individual vessel is identified as a priority vessel (0 if not priority vessel, 1 if priority vessel)
Name	Vessel name
Class	Vessel class
Call ID	Unique vessel call identification number
Vessel ID	Unique vessel identification number
Number of Dock Visits	Number of docks the vessel visits during this vessel call
Arrival Time	Time stamp of vessel arrival to the system
Entry Time	Time stamp of vessel entry into the system
Exit Time	Time stamp of vessel exit from system
Net Time	Calculated duration of the vessel call derived from the difference between the stored entry and stored exit time.
Total Time	Duration of the vessel call
Delay Counter	Total number of waits or delay events during the vessel call (hours)
Waiting Dock	Time vessel spends waiting at docks (hours)
At Dock	Time vessel spends at docks (performing cargo exchanges or other activities in non-delay status) (hours)
Docking	Time vessel spends executing docking maneuvers (hours)

HEADING	DESCRIPTION
Undocking	Time vessel spends executing undocking maneuvers (hours)
Waiting at Entry	Time vessel spends waiting at the entry point (hours)
Waiting Facility Node	Time vessel spends waiting at anchorages (hours)
Total in Reaches	Total time vessel spends transiting reaches (hours)
Vessel Path	The path taken by the vessel from entry to exit including docks and turning basins
Node	Name of anchorage where the vessel is delayed
Type	The type of node where delayed (FN indicates anchorage)

C.4.2 qryRuleViolationsWithPath

The Rule Violations with Path query adds the vessel path to the Rule Violations table (Section C.3.2). This provides additional details on the vessel's intended route while delayed. Such information can be used to ascertain if vessels transiting a particular path are more prone to specific types of delays.

For this query to function the Individual Vessel Call outputs must be generated during the simulation using the MDB Output Control flag.

HEADING	DESCRIPTION
Priority Run	Flag to indicate if the data was generated during the priority vessel run (0 if not priority run, 1 if priority run)
Class	Vessel class
Iteration	Iteration number, starting at one
Current Time	Time stamp of rule violation / trigger
Situation	General location of vessel when rule was triggered (arrival, dock departure, anchorage departure)
Location	Specific location of vessel when rule trigger occurred (named node in network)
MV Call ID	Call ID of the moving vessel
MV Name	Name of the moving vessel
Reach	Reach where rule was triggered
Reach Description	Description of location of rule violation

HEADING	DESCRIPTION
Rule Description	Description of the rule violated
Port Rule	Y / N flag identifying the rule as a port level rule
Transit Rule Number	Number of the rule violated
Applicable Condition	Day, Night, Always
MV LOA, Beam, Capacity, Draft, Type, Class, Underkeel Clearance	Physical parameters of the moving vessel
OV LOA, Beam, Capacity, Draft, Type, Class, Underkeel Clearance	Physical parameters of the other vessel (applicable for multiple vessel rules)
Status	0 indicates no conflict (no other vessel is involved) 1 indicates passing (2 vessels moving in opposite directions) 2 indicates overtaking (2 vessels moving in the same direction) 3 indicates overtaken (2 vessels moving in the same direction)
OV Priority	0 for non-protocol, 1 for protocol vessel
Rule Parameters	Parameters of the rule triggered
MV Reach Entry, Exit	Simulation time that moving vessel enters, exits reach
Reach Width, Depth	Physical dimensions of reach where rule violation occurred
Minimum, Maximum Tide	Minimum / Maximum depth availability due to tide
Message	Description of rule trigger conditions
Vessel Path	The path taken by the vessel from entry to exit including docks and turning basins

C.4.3 qryWaitCause2WithoutDeletedVessels

The Wait Cause 2 without Deleted Vessels query filters the Wait Cause 2 (Section C.3.15) table to remove all deleted vessel calls. Vessels remaining in the system after the simulation time ends are still included in this table.

For this query to function the Deleted Vessel Call and Wait Cause 2 outputs must be generated during the simulation using the MDB Output Control flag.

HEADING	DESCRIPTION

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Current Time	Time measurement in hours of time into iteration
Vessel Call ID	Unique vessel call identification number
Situation	General location of vessel when rule was triggered (arrival, dock departure, anchorage departure)
Location	Specific location of vessel when rule trigger occurred (named node in network)
Wait Increment	Duration of delay
Total Causes	Number of rule/reach combinations contributing to the delay
Combined Code	Numerical representation of combined delay code
Combined String	Combined delay code using the abbreviations in Table 2
VSC, C, BZ, T, AVSU. AVN. AD, TAVN, TAD, TAVSU, DVSU, DVN	General rule type, as defined in Table 2; number entry represents the number of rule triggers of that type contributing to the delay

C.4.4 qryWaitCause2WithoutDeletedOrRetained

The Wait Cause 2 without Deleted Vessels or Retained query filters the Wait Cause 2 (Section C.3.15) table to remove all deleted vessel calls and all vessels remaining in the system at the end of the simulation. The fields in this table match those outlined in Section C.4.3, qryWaitCause2WithoutDeletedVessels.

For this query to function the Deleted Vessel Call, Wait Cause 2, and Vessels Remaining in System outputs must be generated during the simulation using the MDB Output Control flag.

C.4.5 qryWaitCauseWithoutDeletedVessels

The Wait Cause without Deleted Vessels query filters the Wait Cause (Section C.3.14) table to remove all deleted vessel calls.

For this query to function the Deleted Vessel Call and Wait Cause outputs must be generated during the simulation using the MDB Output Control flag.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Priority Run	Flag to indicate if the data was generated during the priority vessel run (0 if not priority run, 1 if priority run)
Priority Vessel	Flag to indicate if the individual vessel is identified as a priority vessel (0 if not priority vessel, 1 if priority vessel)

HEADING	DESCRIPTION
Current Time	Time stamp of rule violation / trigger
Vessel Call ID	Unique vessel call identification number
Rule Type Number	Rule type that causes the delay
Reach Number	Reach where rule was triggered
Rule Type	General rule type
Wait Increment	Duration of delay
Situation	General location of vessel when rule was triggered (arrival, dock departure, anchorage departure)
Location	Specific location of vessel when rule trigger occurred (named node in network)
Call ID	ID number of vessel call, assigned by HarborSym

C.4.6 qryWaitCauseWithoutDeletedOrRetained

The Wait Cause without Deleted or Retained query filters the Wait Cause (Section C.3.14) table to remove all deleted vessel calls and all vessels remaining in the system at the end of the simulation. The fields in this table match those outlined in Section C.4.5, qryWaitCauseWithoutDeletedVessels.

For this query to function the Deleted Vessel Call, Wait Cause, and Vessels Remaining in System outputs must be generated during the simulation using the MDB Output Control flag.

C.4.7 qsumFacilityNodeUsageByPathIteration

The Facility Node Usage by Path Iteration summation query provides a grouping of total wait time at each anchorage by path and iteration.

For this query to function the Individual Vessel Call and Usage outputs must be generated during the simulation using the MDB Output Control flag.

HEADING	DESCRIPTION
Sum of Waiting Facility Nodes	Total time all vessels spend waiting at an anchorage
Node	Name of anchorage where the vessel is delayed
Type	The type of node where delayed (FN indicates anchorage)
Iteration	Iteration number, starting at one
Count of Call ID	Number of vessel calls directed to the anchorage during the iteration
First of Vessel Path	The path taken by the vessel from entry to exit including docks and turning basins

C.4.8 qsumRuleVioloationsWithPath

The Rule Violations with Path summation query provides a count of the number of specific rule / reach triggers incurred by each vessel call.

For this query to function the Individual Vessel Call outputs must be generated during the simulation using the MDB Output Control flag.

HEADING	DESCRIPTION
Priority Run	Flag to indicate if the data was generated during the priority vessel run (0 if not priority run, 1 if priority run)
Class	Vessel class
MV Name	Name of the moving vessel
Reach Description	Description of location of rule violation

HEADING	DESCRIPTION
Rule Description	Description of the rule violated
Iteration	Iteration number, starting at one
Path	The path taken by the vessel from entry to exit including docks and turning basins
Count of Iteration	Number of triggers per iteration

C.4.9 qsumWaitBySituationClassNoDeletedOrRetained

The Wait by Situation Class No Deleted or Retained summation query provides a total wait time by situation and vessel class.

For this query to function the Individual Vessel Call, Deleted Vessel Call, Wait Cause 2, and Vessels Remaining in System outputs must be generated during the simulation using the MDB Output Control flag.

HEADING	DESCRIPTION
Class	Vessel class
Situation	General location of vessel when rule was triggered (arrival, dock departure, anchorage departure)
Total Wait	Sum of delay duration for all vessels delayed within the class, situation, and iteration
Count of Call ID	Count of vessel calls contributing to the total delay duration

C.4.10 qsumWaitBySituationNoDeletedOrRetained

The Wait by Situation No Deleted or Retained summation query provides a total wait time by situation.

For this query to function Deleted Vessel Call, Wait Cause 2, and Vessels Remaining in System outputs must be generated during the simulation using the MDB Output Control flag.

HEADING	DESCRIPTION
Situation	General location of vessel when rule was triggered (arrival, dock departure, anchorage departure)
Sum of Wait Increment	Sum of delay duration for all vessels delayed within the class, situation, and iteration

C.4.11 qsumWaitCauseTotalTimeByCombinedCode

The Wait Cause Total Time by Combined Code summation query reports the total wait increment by code. This provides a total delay time for each unique combined delay code encountered by all vessels in one iteration combination. The query is built upon qryWaitCause2 (Section C.4.3) and therefore will include vessels remaining in the system after the simulation is complete and deleted vessels.

For this query to function the Wait Cause 2 output must be generated during the simulation using the MDB Output Control flag.

HEADING	DESCRIPTION
Priority Run	Flag to indicate if the data was generated during the priority vessel run (0 if not priority run, 1 if priority run)
Combined String	Combined delay code using the abbreviations in Table 2
Sum of Wait Increment	Sum of delay duration for all vessels delayed within the class, situation, and iteration

C.4.12 qsumWaitCauseTotalTimeByCombinedCodeSituationLocation

The Wait Cause Total Time by Combined Code Situation Location summation query reports the total wait increment by code for each situation / location combination. This provides a total delay time for each unique combined delay code encountered by all vessels in one iteration combination. The query is built upon qryWaitCause2 (Section C.4.3) and therefore will include vessels remaining in the system after the simulation is complete and deleted vessels.

For this query to function the Wait Cause 2 output must be generated during the simulation using the MDB Output Control flag.

HEADING	DESCRIPTION
Priority Run	Flag to indicate if the data was generated during the priority vessel run (0 if not priority run, 1 if priority run)
Situation	General location of vessel when rule was triggered (arrival, dock departure, anchorage departure)
Location	Specific location of vessel when rule trigger occurred (named node in network)
Combined String	Combined delay code using the abbreviations in Table 2
Sum of Wait Increment	Sum of delay duration for all vessels delayed within the class, situation, and iteration

C.4.13 qsumWaitIncrementBySituationandCode

The Wait Increment by Situation and Code summation query reports the total wait increment by code for each situation. This provides a total delay time for each unique combined delay code encountered by a vessel in one iteration. The query is built upon qryWaitCause2 (Section C.4.3) and therefore will include vessels remaining in the system after the simulation is complete and deleted vessels.

For this query to function the Wait Cause 2 output must be generated during the simulation using the MDB Output Control flag.

HEADING	DESCRIPTION
Iteration	Iteration number, starting at one
Priority Run	Flag to indicate if the data was generated during the priority vessel run (0 if not priority run, 1 if priority run)
Vessel Call ID	Vessel Call ID Number
Situation	General location of vessel when rule was triggered (arrival, dock departure, anchorage departure)
Location	Specific location of vessel when rule trigger occurred (named node in network)
Combined String	Combined delay code using the abbreviations in Table 2
Sum of Wait Increment	Sum of delay duration for all vessels delayed within the class, situation, and iteration

C.4.14 qsumWaitTimeByPathIteration

The Wait Time by Path Iteration summation query reports the total time spent undergoing various activities in the system by vessel path and iteration. This provides insight into vessels on which routes encounter the greatest delays, spend the most time at docks or in anchorages.

For this query to function, the Individual Vessel Call output must be generated during the simulation using the MDB Output Control flag.

HEADING	DESCRIPTION
Vessel Path	The path taken by the vessel from entry to exit including docks and turning basins
Sum of Net Time	The total time in system (calculated based on entry and exit times) for vessel calls traveling the subject path
Sum of Total Time	The total time in system for vessel calls traveling the subject path
Sum of Waiting Dock	The total time waiting at docks for vessels on the path

HEADING	DESCRIPTION
Sum of at Dock	The total time at docks for vessels on the path
Sum of Docking	The total time docking for vessels on the path
Sum of Undocking	The total time undocking for vessels on the path
Sum of Waiting at Entry	The total time waiting at entry for vessels on the path
Sum of at Turning Basin	The total time in turning basins for vessels on the path
Sum of Total in Reaches	The total time transiting reaches by vessels on the path
Sum of Waiting Facility Node	The total time waiting in anchorages for vessels on the path
Iteration	Iteration number, starting at one
Count of Call ID	Number of vessel calls transiting the subject path

C.4.15 qsumWaitTimeByPathIterationClass

The Wait Time by Path Iteration Class summation query reports the total time spent undergoing various activities in the system by vessel path, iteration, and vessel class. This query is similar to the qsumWaitTimeByPathIteration (Section C.4.14) but further refines the data by segregating the information by vessel class.

For this query to function the Individual Vessel Call output must be generated during the simulation using the MDB Output Control flag.

The fields in this table match those of qsumWaitTimeByPathIteration (Section C.4.14), with the addition of "Class", which identifies the vessel class.

C.4.16 qsumWaitTimeByPathIterationProtocol

The Wait Time by Path Iteration Protocol summation query reports the total time spent undergoing various activities in the system by vessel path, iteration, and priority run. This query is similar to the qsumWaitTimeByPathIteration (Section C.4.14) but further refines the data by identifying only priority vessels.

For this query to function the Individual Vessel Call output must be generated during the simulation using the MDB Output Control flag.

The fields in this table match those of qsumWaitTimeByPathIteration (Section C.4.14), with the addition of "Priority Run", which identifies the priority vessels.

C.4.17 qsumWaitTimeByPathIterationProtocolClass

The Wait Time by Path Iteration Protocol Class summation query reports the total time spent undergoing various activities in the system by vessel path, iteration, vessel class, and priority run. This query is similar to the query qsumWaitTimeByPathIterationClass (Section C.4.15) but further refines the data by segregating the information by priority vessels.

For this query to function the Individual Vessel Call output must be generated during the simulation using the MDB Output Control flag.

The fields in this table match those of qsumWaitTimeByPathIterationClass (Section C.4.15), with the addition of “Priority Run”, which identifies the priority vessels.

Appendix D

Sample PRN

```
HarborSym Model Run on: 04/11/11 10:17:52
Database: C:\Program Files\HarborSym\Data\CertificationTesting\Wait Times\15\HarborSym Certification 2.mdb
IDB: C:\Program Files\HarborSym\Data\CertificationTesting\Wait Times\15\Wait Times before Retry 15.idb
VCDB: C:\Program Files\HarborSym\Data\CertificationTesting\Wait Times\15\Wait Times before Retry 15.vcdb
ODB: C:\Program Files\HarborSym\Data\CertificationTesting\Wait Times\15\HarborSym Certification.odb
```

Documentation of input &output files used in the simulation

```
Model Version:   1.102100
Scenario ID:  1 HS Certification
HS Certification
Iterations: 1 Scenario Duration: 50 Added Duration for Priority Simulation 100
Start Date of Simulation: 01/01/07 00:00:00
```

Description of simulation specifics

```
Seed:           0
Port: HarborSym Certification 2
Latitude:  40.64000 Longitude: -74.14000 UTC Offset:     -5
Daylight Savings Time   Flag 1
        Start     4     1 Day of Week:     1
        End      10    31 Day of Week:     1
Nodes: 4
Reaches: 3
Docks: 1
Facility Nodes: 2
Entrances: 1
```

Network description

```
Rule Application: 1 Use Intermediate Facility Nodes: 1
Priority Vessels: 1 Tide: 0
Commodity Categories
                    Crude Oil Safety Zone Type:         Never Distance:     0.000  Units: Tons TonsPerUnit:      1.000 Critical: N
                        Grain Safety Zone Type:         Never Distance:     0.000  Units: Tons TonsPerUnit:      1.000 Critical: N
```

Information on commodity categories

```
Route Groups
ID:      1   Default RtGrp Prior  Triangular      1.000      1.000      1.000 LD:     85.000 Next  Triangular      1.000      1.000      1.000 LD:     85.000

Configuration Settings
                   FeetPerCoordinateUnit        1.000000
          HoursAddedToPrioritySimulation      100.000000
               OutputWindowDurationBegin       -1.000000
                 OutputWindowDurationEnd  1000000.000000
              OutputWindowIterationBegin       -1.000000
                OutputWindowIterationEnd 10000000.000000
          TimeWaitingAtDockCostThreshold        2.000000
         TimeWaitingAtEntryCostThreshold        0.500000
  TimeWaitingAtFacilityNodeCostThreshold        2.000000
       VesselDraftLimit_TidalRangeParameter     0.750000
         VesselDraftLimit_TidalTimeInterval    72.000000
                   VesselLegWaitLimit_Count   100.000000
End Configuration Settings
```

Configuration settings used in simulation

```
Output Files Activated
Iteration
Certification
DraftAdjustment2
VesselCallProblem
VesselCall
VesselClassStatistics
NodeScheduling
NodeConstraint
DeletedVesselCall
Commodity
DraftAdjustment
RuleViolation
WaitCause2
VesselsRemainingInSystem
End Output Files
```

Output files generated during simulation

```
I:     1 All Vessels Run Vessel Calls:      4 Remaining:      0 Deleted On Wait:      0 Exiting:      4 Unstored Vessels From Priority Run:      0
Iteration:     1 Facility Node:      0              Anchorage Vessel Sends:     1
Computation Time (seconds):     13.000

Maximum Number of Priority Vessel Calls 0
Number of Reaches In Call - Max: 6 Min: 6
Total Number of Draft Adjustments (all iterations): 4

Simulation Output
================================
                          N        Average          SD          Max          Min
# in Call List            1              4           0            4            4
# Vessels Exiting         1              4           0            4            4
Avg Ves Time in System    4         12.587       3.294       15.750        9.500
Tot Vessel Cost (000)     1         50.350       0.000       50.350       50.350
Avg Vessel Cost (000)     4         12.587       3.294       15.750        9.500
Avg Ves Time Waiting      4          1.837       1.850        3.600        0.000
Avg Ves Time Reaches      4          6.000       0.000        6.000        6.000
Avg Ves Time Loading      4          3.250       1.500        5.000        2.000
Avg Ves Time TB           4          0.500       0.000        0.500        0.500
Avg Ves Time Docking      4          0.500       0.000        0.500        0.500
Avg Ves Time Undocking    4          0.500       0.000        0.500        0.500
Avg Ves Time Wait Entry   4          0.688       1.375        2.750        0.000
Avg Ves Time Wait Dock    4          0.250       0.289        0.500        0.000
Avg Ves Time Waiting FN   4          0.900       1.800        3.600        0.000
Total Time in System      1         50.350       0.000       50.350       50.350
Total Commodity Tons      1     44,000.000       0.000   44,000.000   44,000.000
Total Tons/Tot Time       1        873.889       0.000      873.889      873.889
Total Wait in System      1          7.350       0.000        7.350        7.350
Time in Reaches           1         24.000       0.000       24.000       24.000
Time Docking              1          2.000       0.000        2.000        2.000
Time UnDocking            1          2.000       0.000        2.000        2.000
Time Loading              1         13.000       0.000       13.000       13.000
Time in TB                1          2.000       0.000        2.000        2.000
Wait at Entry             1          2.750       0.000        2.750        2.750
Wait at Dock              1          1.000       0.000        1.000        1.000
Wait at FN                1          3.600       0.000        3.600        3.600
Sea Cost (000)            1          0.800       0.000        0.800        0.800
Allocated Cost (000)      1         50.350       0.000       50.350       50.350
InReaches Cost (000)      1         24.000       0.000       24.000       24.000
WaitEntry Cost (000)      1          2.750       0.000        2.750        2.750
Docking Cost (000)        1          2.000       0.000        2.000        2.000
Undocking Cost (000)      1          2.000       0.000        2.000        2.000
AtDock Cost (000)         1         13.000       0.000       13.000       13.000
WaitDock Cost (000)       1          1.000       0.000        1.000        1.000
AtTB Cost (000)           1          2.000       0.000        2.000        2.000
WaitFN Cost (000)         1          3.600       0.000        3.600        3.600
TotalPort Cost (000)      1         50.350       0.000       50.350       50.350
TotalSea Cost (000)       1          0.800       0.000        0.800        0.800
OverallTotal Cost (000)   1         51.150       0.000       51.150       51.150

Reach Rule Violation Statistics

Statistics By Vessel Class


Tanker Priority: N
Avg Ves Time in System    2         12.300       3.960       15.100        9.500
Avg Ves Time Waiting      2          1.800       2.546        3.600        0.000
```

Description of vessel calls processed in each iteration

Simulation output provides statistics generated over all iterations

Summary statistics for each vessel class. "N" represents the number of observed calls by each class.

Avg Ves Time Reaches	2	6.000	0.000	6.000	6.000
Avg Ves Time Loading	2	3.000	1.414	4.000	2.000
Avg Ves Time TB	2	0.500	0.000	0.500	0.500
Avg Ves Time Docking	2	0.500	0.000	0.500	0.500
Avg Ves Time Undocking	2	0.500	0.000	0.500	0.500
Avg Ves Time Wait Entry	2	0.000	0.000	0.000	0.000
Avg Ves Time Wait Dock	2	0.000	0.000	0.000	0.000
Avg Ves Time Waiting FN	2	1.800	2.546	3.600	0.000
Avg Ves Total Cost	2	12,499.9	3,959.8	15,299.9	9,699.9
Avg Ves Port Cost	2	12,299.9	3,959.8	15,099.9	9,499.9
Avg Ves Sea Cost	2	200.0	0.0	200.0	200.0
Avg Ves QImp: Tons	2	0.0	0.0	0.0	0.0
Avg Ves QExp: Tons	2	15,000.0	7,071.1	20,000.0	10,000.0
Avg Ves TonsImp: Tons	2	0.0	0.0	0.0	0.0
Avg Ves TonsExp: Tons	2	15,000.0	7,071.1	20,000.0	10,000.0
Avg Ves $_Imp: Tons	2	0.0	0.0	0.0	0.0
Avg Ves $_Exp: Tons	2	0.0	0.0	0.0	0.0
Class $ Per Ton: Tons	1	0.8	0.0	0.8	0.8
InReaches	1	11,999.8	0.0	11,999.8	11,999.8
WaitEntry	1	0.0	0.0	0.0	0.0
Docking	1	1,000.0	0.0	1,000.0	1,000.0
Undocking	1	1,000.0	0.0	1,000.0	1,000.0
AtDock	1	6,000.0	0.0	6,000.0	6,000.0
WaitDock	1	0.0	0.0	0.0	0.0
AtTB	1	1,000.0	0.0	1,000.0	1,000.0
WaitFN	1	3,600.0	0.0	3,600.0	3,600.0
TotalPort	1	24,599.8	0.0	24,599.8	24,599.8
TotalSea	1	400.0	0.0	400.0	400.0
OverallTotal	1	24,999.8	0.0	24,999.8	24,999.8
Bulker Priority: N					
Avg Ves Time in System	2	12.875	4.066	15.750	10.000
Avg Ves Time Waiting	2	1.875	1.945	3.250	0.500
Avg Ves Time Reaches	2	6.000	0.000	6.000	6.000
Avg Ves Time Loading	2	3.500	2.121	5.000	2.000
Avg Ves Time TB	2	0.500	0.000	0.500	0.500
Avg Ves Time Docking	2	0.500	0.000	0.500	0.500
Avg Ves Time Undocking	2	0.500	0.000	0.500	0.500
Avg Ves Time Wait Entry	2	1.375	1.945	2.750	0.000
Avg Ves Time Wait Dock	2	0.500	0.000	0.500	0.500
Avg Ves Time Waiting FN	2	0.000	0.000	0.000	0.000
Avg Ves Total Cost	2	13,074.9	4,065.9	15,949.9	10,199.9
Avg Ves Port Cost	2	12,874.9	4,065.9	15,749.9	9,999.9
Avg Ves Sea Cost	2	200.0	0.0	200.0	200.0
Avg Ves QImp: Tons	2	5,000.0	7,071.1	10,000.0	0.0
Avg Ves QExp: Tons	2	2,000.0	2,828.4	4,000.0	0.0
Avg Ves TonsImp: Tons	2	5,000.0	7,071.1	10,000.0	0.0
Avg Ves TonsExp: Tons	2	2,000.0	2,828.4	4,000.0	0.0
Avg Ves $_Imp: Tons	2	0.0	0.0	0.0	0.0
Avg Ves $_Exp: Tons	2	0.0	0.0	0.0	0.0
Class $ Per Ton: Tons	1	1.9	0.0	1.9	1.9
InReaches	1	11,999.8	0.0	11,999.8	11,999.8
WaitEntry	1	2,750.0	0.0	2,750.0	2,750.0
Docking	1	1,000.0	0.0	1,000.0	1,000.0
Undocking	1	1,000.0	0.0	1,000.0	1,000.0
AtDock	1	7,000.0	0.0	7,000.0	7,000.0
WaitDock	1	1,000.0	0.0	1,000.0	1,000.0
AtTB	1	1,000.0	0.0	1,000.0	1,000.0
WaitFN	1	0.0	0.0	0.0	0.0
TotalPort	1	25,749.8	0.0	25,749.8	25,749.8
TotalSea	1	400.0	0.0	400.0	400.0

Summary statistics for each vessel class. "N" represents the number of observed calls by each class.

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Appendix E

Loading Tools Output Files

The output files generated by the CLT and BLT are described in this Appendix.

E.1 Container Loading Tool Output Files

E.1.1 CommodityTransfer-CLT.csv

HEADING	DESCRIPTION
Iteration	Iteration number
Vessel	Named of generated vessel, named according to vessel type
Commodity	Name of commodity
Forecast	User-defined unique forecast identification, from CommodityForecastDescription in Commodity Forecast at Dock table
ImportQuantity	Quantity imported on vessel, in metric tons
ExportQuantity	Quantity exported on vessel, in metric tons

E.1.2 Fleet-CLT.csv

HEADING	DESCRIPTION
Iteration	Iteration number
FleetSpecification	User-defined fleet specification description, from Container Fleet Specification Table
Season	Season description
Service	Service name
VesselClass	Vessel class description
AllocationPriority	Allocation priority specified in the Container Fleet Specification Table
AvailableVisits	Maximum port visits specified in the Container Fleet Specification Table
VisitsUsed	Number of visits used to satisfy the forecast

E.1.3 FleetUsageStatistics-CLTL.csv

HEADING	DESCRIPTION
FleetSpecification	User-defined fleet specification description, from Container Fleet Specification Table
Season	Season description
Service	Service name
Class	Vessel class description
AllocationPriority	Allocation priority specified in the Container Fleet Specification Table
MaxPortVisits	Maximum port visits specified in the Container Fleet Specification Table
Average	Average number of port visits used by iteration
SD	Standard deviation of number of port visits used by iteration (if only generated a single iteration, then field will be populated with "NaN")
Max	Maximum number of port visits used by iteration
Min	Minimum number of port visits used by iteration

E.1.4 Forecast-CLT.csv

HEADING	DESCRIPTION
Iteration	Iteration number
CommodityForecast	User-defined unique forecast identification, from CommodityForecastDescription in Commodity Forecast at Dock table
Season	Season description
Dock	Dock ID code
Region	Region name
Commodity	Name of commodity
ImportForecast	Quantity of commodity forecasted to be imported (randomly drawn value between ImportQuantity and plus or minus one ImportQuantitySD, defined by user in Commodity Forecast by Dock Table)
ImportAssigned	Quantity of imports loaded on vessels, in metric tons
ExportForecast	Quantity of commodity forecasted to be imported (randomly drawn value between ExportQuantity and plus or minus one ExportQuantitySD, defined by user in Commodity Forecast by Dock

HEADING	DESCRIPTION
	Table)
ExportAssigned	Quantity of exports loaded on vessels, in metric tons
VesselsUsed	Number of vessels used to satisfy the forecast

E.1.5 SatisfactionStatistics-CLT.csv

HEADING	DESCRIPTION
Forecast	User-defined unique forecast identification, from CommodityForecastDescription in Commodity Forecast at Dock table
Season	Season description
Dock	Dock ID code
Region	Region name
Commodity	Name of commodity
ExportAverage	Average percent of exports allocated to vessels, averaged by iteration
ExportSD	Standard deviation of percent of exports allocated to vessels by iteration (note, field will be populated with "NaN" if only a single iteration is ran)
ExportMax	Maximum percent of exports allocated to vessels over iterations
ExportMin	Minimum percent of exports allocated to vessels over iterations
ImportAverage	Average percent of imports allocated to vessels, averaged by iteration
ImportSD	Standard deviation of percent of imports allocated to vessels by iteration (note, field will be populated with "NaN" if only a single iteration is ran)
ImportMax	Maximum percent of imports allocated to vessels over iterations
ImportMin	Minimum percent of imports allocated to vessels over iterations

E.1.6 Vessels-CLT.csv

HEADING	DESCRIPTION
Iteration	Iteration number
VesselName	Named of generated vessel, named according to vessel type
UniqueVesselID	Unique vessel ID, as required by HarborSym

HEADING	DESCRIPTION
ClassName	Vessel Class description
SubClassName	Vessel Subclass name
AllocationPriority	Allocation priority assigned to unique vessel, according to that specified in the Container Fleet Specification Table for vessel classes
ArrivalDate	Time and date vessel arrived at port of study
Dock	Dock ID code visited by vessel
Service	Service name associated with vessel
RouteGroup	Route Group name associated with vessel
Loading	Tonnage on Vessel at Arrival
ImportTons	Metric tons unloaded from vessel for import
ExportTons	Metric tons loaded on vessel for export
LOA	CLT-generated Length Overall for vessel
Beam	CLT-generated beam for vessel
Capacity	CLT-generated capacity for vessel
ForecastCount	# of distinct forecasts that this vessel call has satisfied in whole or part
ArrivalDraft	Draft of vessel when arriving at port
Forecast	User-defined unique forecast identification, from CommodityForecastDescription in Commodity Forecast at Dock table

E.1.7 LoadingAnalysis-CLT.csv

HEADING	DESCRIPTION
Iteration	Iteration number
Vessel	Named of generated vessel, named according to vessel type
SubClass	Vessel Subclass name
TEURating	TEU Rating for Vessel Subclass (echo of user input in database)
DesignDraft	Maximum Summer Load Line Draft (echo of user input in database)
DWTRatingMXSLLD	Capacity At Maximum Summer Load Line Draft (echo of user input in database)

HEADING	DESCRIPTION
WorkingTPI	Working Tons Per Inch Displacement (echo of user input in database)
TotalUKCRequirement	Sum of Baseline Underkeel Clearance and Sinkage Adjustment (from user input in database)
TentativeArrivalDraft	Randomly drawn (CDF or uniform distribution) arrival draft, before applying constraints
MaxAllowableArrivalDraft	Maximum allowable arrival draft after prior port constraints and tide and sea level change adjustments
ArrivalDraft	Final arrival draft used in calculations
ArrivalDraftAdjusted	Have adjustments been made to arrival draft (i.e. final calculation is not equal to tentative)
TentativeDepartureDraft	Calculated departure draft, based on arrival draft and net tonnage transfer at port. Will be 0 unless situation is "AfterLoadVessel"
MaxAllowableDepartureDraft	Maximum allowable departure draft taking into account subsequent port constraints, tide and sea level change adjustments
DepartureDraft	Minimum of tentative departure draft and Max allowable departure draft
DepartureDraftAdjusted	Have adjustments been made to departure draft (i.e. final departure draft is not equal to tentative)
LimitingDepthAtDock	User input maximum depth at dock (does not include underkeel clearance requirement or tide), from dock information in IDB
TidalAvailability	User input tidal availability at dock
PriorPortLimitingDepth	Limiting depth of the port previously visited by vessel, obtained from Route Group
NextPortLimitingDepth	Limiting depth of the next port to be visited by vessel, obtained from Route Group
AverageLadingWeightPerLoadedTEU	Average commodity weight per loaded TEU in metric tons, derived by vessel class and service from table Service Vessel Class
AverageContainerWeightPerTEU	Average container weight per TEU in metric tons, derived by vessel class and service from table Service Vessel Class
PercentOfEmptyTEUs	% of TEUs that are empty - User input (service -vessel class)
PercentVacantSlots	% of slots that are not filled - User input (service-vessel class)
PercentVariableBallast	User-specified percentage fraction of the available dead weight tonnage at the vessel arrival draft to account for variable ballast (service-vessel class)

HEADING	DESCRIPTION
PercentAllowanceForOperations	User-specified percentage fraction of the available dead weight tonnage at the vessel arrival draft to account for operations (bunkerage + ships stores) (service-vessel class)
TotalTonnagePerLadenTEU	Weight per laden TEU (cargo only) + empty box weight (for cargo) + allocated fraction of empty box weight (for empties)
PercentForCargo	Average Lading Weight Per Loaded TEU / Total Tonnage Per Laden TEU (fraction of weight that is cargo)
PercentForLadenBoxes	Average Container Weight Per TEU / Total Tonnage per Laden TEU(fraction of weight that is box, for laden boxes)
PercentForEmptyBoxes	Fraction of Weight that is empty boxes
CheckSum	Sum of previous 3 columns, should always be 1.0
MinVacantSlots	Fractional number of vacant slots, based on input TEU rating for vessel and percentage of vacant slots (user input)
PotentiallyOccupiedContainerSlots	TEU rating - Vacant Slots
MaxLoadedContainersDraftBased	Maximum number of loaded containers based on draft
MaxLoadedContainersNominalTEUBased	Maximum number of loaded containers based on available slots, accounting for empty slots
MaxLoadedContainers	Smaller of MaxLoadedContainersDraftBased or MaxLoadedContainersNominalTEUBased (draft vs. cube)
MinEmptyContainers	# of empty containers based on max loaded containers and empty container fraction
VacantSlots	# of vacant slots based on total teu, # of loaded containers and # of empty containers
CheckSum	Check sum, MaxLoadedContainers + MinEmptyContainers + VacantSlots - teuRating, should be 0
DeadWeightTonnageAvailableForVesselDraft	Tonnage available at vessel draft, based on capacity, design draft, arrival draft, and TPI - how much additional tonnage can be loaded on vessel
ApproximateVariableBallast	Tonnage devoted to variable ballast
AllowanceForOperationsInMetricTonnes	Tonnage devoted to allowance for operations
AvailableForCargoDraftBased	Tonnage available for cargo (DeadWeightTonnageAvailableForVesselDraft) less tonnage for ballast less tonnage for operations

HEADING	DESCRIPTION
AvailableForCargoVolumeBased	Tonnage available for cargo based on volume
AvailableForCargo	Lesser of AvailableForCargoDraftBased or AvailableForCargoVolumeBased
MaxWeightForEmptyBoxes	Total weight of empty containers
MaxWeightForCargo	Total weight of cargo (exclusive of box weight)
MaxWeightForLadenBoxes	Total weight of laden containers (box weight only)
TotalWeightBoxPlusCargo	Total weight of cargo plus boxes
MaxDraftCargoBased	Maximum draft under maximum cargo (volume) utilization
VolumeConstrained	True if volume constrained as opposed to draft constrained
InitialAvailableImportCapacity	Calculated amount of arrival tonnage that is available for import
InitialAvailableExportCapacity	Calculated amount of arrival tonnage that is available for export
FinalAvailableImportCapacity	Final remaining capacity on vessel for import (tonnes)
FinalAvailableExportCapacity	Final remaining capacity on vessel for export (tonnes)
TotalImportTonnage	Total tonnage imported to port
TotalExportTonnage	Total tonnage exported from port
IndividualForecastImport	Amount of individual forecast satisfaction for import (meaningful for "Load Vessel" situation only
IndividualForecastExport	Amount of individual forecast satisfaction for export (meaningful for "Load Vessel" situation only
Situation	Refers to status of calculation, 3 rows per vessel: 1) set arrival draft 2) load vessel 3) after loading the vessel

E.1.8 ArrivalDraftDebug.csv

This output file is for debugging and must be “turned on” through the options menu of the CLT.

Type	Indicates draft type
Function	Indicates whether a CDF is stored or if the min/max should be used
Service	Service description
Class	Vessel Class description

Iteration	Iteration number
MinDraft	Minimum draft for the service/vessel class as defined in the Service-Vessel Class table
MaxDraft	Maximum draft for the service/vessel class as defined in the Service-Vessel Class table
Probability	Randomly drawn value
TentativeValue	Tentative arrival draft that falls between the min/max draft calculated with probability
FinalValue	Tentative arrival draft is checked against maximum allowable arrival draft (described in Section 4.2.3)

E.2 Bulk Loading Tool Output Files

E.2.1 Allocation.csv

HEADING	DESCRIPTION
Iteration	Iteration number
Forecast	Forecast identification number
CommodityCategory	Commodity category name
DockCode	Dock ID code
ForecastQuantityImport	Import quantity specified for forecast in tons
ForecastQuantityExport	Export quantity specified for forecast in tons
AllocatedImport	Import quantity allocated to vessels in tons
AllocatedExport	Export quantity allocated to vessels in tons
NumberOfUniqueVessels	Count of unique vessels generated to satisfy forecast
NumberOfCalls	Count of vessel calls generated to satisfy forecast
ImportDeficit	Import quantity not allocated to vessels, therefore deficit in tons
ExportDeficit	Export quantity not allocated to vessels, therefore deficit in tons

E.2.2 ClassUsage.csv

HEADING	DESCRIPTION
Iteration	Iteration number
VesselClass	Vessel class name
ShortName	Vessel class description
Vessels	Count of vessels generated to satisfy import and export forecast
Calls	Count of vessel calls generated to satisfy import and export forecast
AllocationPriority	Notes allocation priority of vessel class

E.2.3 Loading.csv

HEADING	DESCRIPTION
VesselName	Name of Synthetic Vessel
Dock	Dock Code
Commodity	Commodity Imported or Exported
Class	Vessel Class
QUnitsToBeAllocImport	Commodity Units Imported (based on draft and capacity constraints)
QUnitsToBeAllocExport	Commodity Units Exported (based on draft and capacity constraints)
UnderkeelClearance	Vessel underkeel clearance
LoadingFactorImport	Fraction of vessel DWT that can be used for loading on import, based on triangular distribution stored in vessel class-commodity category table (FCDB)
LoadingFactorExport	Fraction of vessel DWT that can be used for loading on export, based on triangular distribution stored in vessel class-commodity category table (FCDB)
DockLimitingDepth	Limiting depth at processing dock
PriorPortLimitingDepth	Prior port limiting depth, based on assigned route group
NextPortLimitingDepth	Next port limiting depth, based on assigned route group
LimitingDepthImport	Critical limiting depth for import based on prior port limiting depth, dock limiting depth, or design draft; -1 indicated no import
LimitingDepthExport	Critical limiting depth for export based on next port limiting depth,

HEADING	DESCRIPTION
	dock limiting depth, or design draft; -1 indicates no export
DWT	Vessel capacity in dead weight tons (DWT)
TPIFactor	Vessel TPI factor
AllowanceForOperationsFraction	The looked up fraction of DWT that is assigned to allowance for operations from the Allowance for Operations curve found in the installed file ‘AllowanceForOperations.csv’
AllowanceForOperationsTons	Total tons for Allowance for Operations, equal to DWT times AllowanceForOperationsFraction
AllowanceForOperationsAdditionalImmersion	Draft that is allocable to AllowanceForOperationsTons, based on TPI calculations
TentativeLoadingImportTons	Loading for Import with or without adjustment for allowance for operations; without adjustment = DWT * LoadingFactorImport; with adjustment = DWT – Tons associated with allowance for operations
AdditionalDraftImport	Tentative Import Loading / TPI Factor/12.0, in feet
TotalDraftImport	Pre-Adjustment Import Draft = Empty Vessel Draft + Underkeel Clearance + Tentative Additional Draft Import (associated with tentative import loading) + Draft associated with allowance for operations
ExcessDraftImport	Draft Beyond Limits (either limiting depth or design draft) that will need to be reduced by lowering tentative import quantity
TonsToReduceImport	Conversion of Excess Draft to Tons via TPI factor
QuantityLoadedImportTons	Tentative Import Quantity Less Tons To Reduce Adjustment
TentativeLoadingExportTons	Loading for Export with or without adjustment for allowance for operations; without adjustment = DWT * LoadingFactorImport; with adjustment = DWT – Tons associated with allowance for operations
AdditionalDraftExport	Tentative Export Loading / TPI Factor/12.0, in feet
TotalDraftExport	Pre-Adjustment Export Draft = Empty Vessel Draft + Underkeel Clearance + Additional Draft Export (associated with tentative export loading) + Draft associated with allowance for operations
ExcessDraftExport	Draft Beyond Limits (either limiting depth or design draft) that will need to be reduced by lowering tentative export quantity
TonsToReduceExport	Conversion of Excess Draft to Tons via TPI factor
QuantityLoadedExportTons	Tentative Export Quantity Less Tons To Reduce Adjustment

HEADING	DESCRIPTION
EmptyVesselDraft	Draft of the vessel if empty of cargo, stores, fuel, etc.
DesignDraft	Class-based randomized vessel design draft
MinimumClassSailingDraft	Class-based minimum sailing draft (input data)
MaximumClassSailingDraft	Class-based maximum sailing draft (input data)
ArrivalDraft	Final calculated sailing draft of vessel upon arrival at the port
QuantityImportedUnits	Final quantity on vessel at import (units)
QuantityExportedUnits	Final quantity on vessel at export (units)
TonsPerUnit	Tons Per Unit Conversion (from commodity information, user input)
QuantityLoadedImportTons	QuantityImportedUnits Converted To Tons Via Conversion Factor
QuantityLoadedImportUnits	Identical to QuantityImportedUnits (no longer needed)
QuantityLoadedExportTons	QuantityExportedUnits Converted To Tons Via Conversion Factor
QuantityLoadedExportUnits	Identical to QuantityExportedUnits (no longer needed)

E.2.4 Vessel.csv

HEADING	DESCRIPTION
Iteration	Iteration number
VesselName	Unique vessel name
ClassDescription	Vessel class description
ClassID	Vessel class ID
ClassNumber	Vessel class number
Allocation	Allocation priority of vessel
Interarrival	Not currently used
InterarrivalSD	Not currently used
MinimumCapacity	Class-based minimum capacity
MaximumCapacity	Class-based maximum capacity
LOA	Randomly assigned length overall, based on vessel-class level statistics
Beam	Randomly assigned length overall, based on vessel-class level statistics

Draft	Randomly assigned length overall, based on vessel-class level statistics
DWT	Randomly assigned length overall, based on vessel-class level statistics
TPIFactor	Randomly assigned length overall, based on vessel-class level statistics
MinimumDraft	Minimum draft based on design draft and capacity
NumberOfAvailableCalls	Always 1
NumberOfAllocatedCalls	1 if vessel is assigned a trip and is in the VCDB, 0 otherwise
MaximumNumberOfTrips	Always 1
TotalTimeInTrips	Not currently used
LoadingFactorImport	Fraction of vessel DWT that can be used for loading on import, based on triangular distribution stored in vessel class-commodity category table (FCDB)
LoadingFactorExport	Fraction of vessel DWT that can be used for loading on export, based on triangular distribution stored in vessel class-commodity category table (FCDB)
AllowanceForOperations	Fraction of vessel capacity that is to be used for operations and thus not available for cargo loading. Derived according to the vessel's DWT and standards for allowance for operations provided by IWR.

Glossary

Glossary Term	Glossary Definition
Allowance for Operations	The fraction of a vessel capacity that is to be used for operations and thus not available for cargo loading
Anchorages	Designated node where vessels wait intermediately if prohibited from reaching its destination due to congestion or constraints
Bulk Loading Tool (BLT)	Module integrated within HarborSym designed to generate synthetic non-containerized vessels
Commodities	Cargo that is loaded and unloaded from a vessel at the harbor docks
Commodity Transfer	Loading or unloading of one commodity from one vessel during a dock visit
Commodity Transfer Rate	The rate at which a commodity, or cargo, is loaded or unloaded from a vessel in units per hour
Critical Commodity	Commodity designation that restricts meeting (passing or overtaking) of two vessels within a reach if either vessel is carrying a critical commodity; the critical commodity rule must be established within the reach for restriction to apply
Current Station	Stations from which the flow of current is measured
Dock Visit	Single visit by a vessel to a dock
Duration	Scenario parameter defining the hours for a simulation
Entry/Exit Point	Nodes where vessels enter or exit the harbor
ETTC	Estimate of total trip cargo; defined as the cargo on board at arrival plus the cargo on board at departure, in tons
Iteration	Scenario parameter defining the number of durations
Leg	Contiguous set of reaches between stopping points
Meeting	Refers to both passing and overtaking
Multiple Vessel Rule	Vessel transit rule that involves encounters between two vessels; parameters must be entered for the moving vessel and the "other" vessel
Nodes	Docks, turning basins, anchorages, entry/exit points, or other topological points in the harbor where channel conditions change
Overtaking	Two vessels moving in the same direction in a channel reach

Passing	Bi-directional movement of two vessels within a reach
Port	Synonymous with the study harbor, represented in HarborSym as a system of reaches between nodes
Priority Vessel	Special designation within HarborSym; allowed to travel through the system unimpeded
Project	Definition of a harbor, including all the physical characteristic of the docks, turning basins, anchorages, and reaches within the harbor; includes vessel transit rules; projects within a study can have the same vessel call list
Reach	Segment of channel between two nodes with uniform characteristics, including width, depth, transit rules, and operating speeds
Route Group	Named itinerary or portion thereof that a vessel may travel before and after visiting the port of study
Safety Zone	Distance from the ship's bow and stern that is restricted sailing space; safety zones are user defined characteristics specified according to the commodity carried on a vessel
Scenario	Set of defined run parameters that specify the conditions of a simulation
Service	Regular vessel transit across a set of regions
Single Vessel Rule	Vessel transit rule that involves only a single vessel; parameters are entered for only the moving vessel
Study	The designation for the overall analysis conducted with the model; limited to one contiguous geographic area; contains at least one project
Tidal Station	Stations at which tides are measured
Tons per Square Inch (TPI)	The number of tons required to change the draft of a vessel by one inch at a given draft, expressed in inches
Turning Basin	Designated node where vessels complete turning maneuvers
Vessel Call	Single port visit by vessel where dock visit(s) and commodity transfers occur
Vessel Class	Subset of vessel type; defined by user based upon physical parameters, commodities carried, sailing draft, sailing speeds, operating costs, and ocean sailing routes
Vessel Cost	The product of vessel time in system and vessel operating cost
Vessel Cost at Sea	Costs associated with vessel while transiting reaches, performing turning maneuvers, delays beyond threshold times, and while traversing vessel route at sea
Vessel Cost in Port	Costs associated with vessel applied during dock visits; includes time spend docking and undocking
Vessel Docking	The amount of time a vessel spends docking or undocking designated in hours

Time

Vessel Operating Costs	Defined by vessel status (at sea or in port) and also by vessel flag (foreign or domestic); associated with vessel sailing speed
Vessel Path	Series of legs a vessel travels during a call to the port, including intermediate nodes
Vessel Size Unit (VSU)	Abstract concept that allows the user to provide a multi-dimensional accounting for vessel dimensions; assigned at the vessel class level and applied as a restriction at turning basin and docks
Vessel Speed	The speed, in knots per hour, that a vessel can travel; associated with vessel operating costs; defined in port by reaches and at sea by vessel class
Vessel Time Waiting	Time vessels spend waiting at port nodes to prevent a rule violation; vessels can wait at entrance, dock, or anchorage, expressed in hours
Vessel Transit Rules	User designated restrictions on how vessel are allowed to move through the system
Vessel Turning Time	The amount of time a vessel spends turning in a turning basin in hours
Vessel Type	General category of vessels such as tankers, general cargo vessels, or container vessels, as defined by user
Vessels	Various types of ships that visit the harbor

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